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AN OIL FLUME.

PETROLEUM AND COAL FIELDS OF THE PACIFIC COAST OF ALASKA.

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IN response to a general demand for information, a reconnoissance of the petroleum and coal fields in the vicinity of Controller Bay and Bering River and of the petroleum fields on the west shore of Cook Inlet and at Cold Bay was made by the writer during the months of June, July, and August, 1903, and during the summer of 1904.

These fields, though widely separated, are all on the southern coast of Alaska, and except the Bering River coal fields, on tide water. The Controller Bay petroleum fields are near the mouth of Copper River, and the Cape Yaktag fields are 75 miles farther east. The Cook Inlet fields are about 320 miles west of Controller Bay, and the Cold Bay field is about 160 miles to the southwest. The Bering River coal fields are from 20 to 40 miles from the coast in the valley of Bering River, which flows into Controller Bay. The latter is an indentation of the coast about 100 miles west of Mount St. Elias, and is sheltered by Cape Suckling and a group of islands. The area herein discussed includes the shores of Controller Bay and the adjacent region. To the north rise the foothills of the Chugach Mountains, while the eastern shore of the bay and of Bering River is low and almost flat.

Bering River with its tributaries drains the central part of this region and flows through a lake of the same name, which is about 10 miles from the sea. The region is also drained by the Katalla River, the Nitchawak River, and numbers of small streams. Most of the lowlands and the foothills to an elevation of about 1,000 feet are covered with a dense forest, principally of good spruce and hemlock.

The various companies interested in the development of this region have built trails from cabin to cabin, and land travel is confined to these, to a good wagon road, and to two short trams. The network of rivers, however, makes it very easy to get about in small boats, and a great part of the travel is done in that way. Kayak on Wingham Island, a steamer landing for the entire region, is the most important settlement. With the exception of the town of Katalla at the mouth of the river of that name, there are no other settlements except the camps of the various operating companies and several small Indian villages. Kayak and Katalla are post offices.

The rocks include a complex series of semimetamorphosed beds, some oil-bearing shales, a succession of coal measures, a series of Miocene sandstones, conglomerates, and shales, a few igneous rocks, and a large area of alluvial and glacial deposits. The Katalla formation is a series of dark argillaceous and carbonaceous shales with occasional bands of sandstone, limestone, conglomerate, and volcanic ash; it is the series through which the petroleum of the region reaches the surface. The few fossils that have been obtained indicate that this formation is of Tertiary age. The Kushtaka formation, a name here proposed for a coal-bearing series of strata, exposed in the valley of the Bering River and its tributaries and on the shore of Lake Kushtaka, consists of an unknown thickness of shale, arkosic sandstone, and coal seams. It is distinguished from the Katalla formation by the presence of these coal seams, the predominance of sandstone over shale, and the coarseness of the sediments. Numerous masses of igneous rock are found in the Bering River region. At the southern end of Wingham Island are good exposures of horizontal or gently dipping, unconsolidated sand, clays, and gravels. The eastern shore of Bering River and Controller Bay for a considerable distance is a flat plain of sand and mud, constantly growing by the addition of sediment which the streams from the southwestern margin of the Bering glacier deposit. Another series of deposits contemporaneous with the last, yet different in origin, are the beaches, islands, and bars which the waves of the ocean are building along these shores.

The prevailing strike is northeast and southwest, and the prevailing dip is from 35 deg. to 60 deg. The region between Bering Lake and Controller Bay consists of an undetermined number of parallel, closely-folded anticlines and synclines with pitching axes, of which the average direction is N. 35 deg. E. The most plainly developed of these folds are the Katalla Valley anticline, the Strawberry Point syncline, and the Chilkat Creek anticline. The structure of that part of the coal area which was visited by the writer is rather simple. The strike is fairly regular in direction (N. E. and S. W.) and the dip is chiefly northwestward. The uncertain factor is the total amount of influence of the faults.

Petroleum seepages are very abundant in the Controller Bay region. The flow of oil at those about 4 miles east of Katalla is very large, and good-sized pools have collected on the surfaces. At another group of seepages on the head-waters of Burls Creek the quantity of petroleum showing is not so large, but it is more widespread. Seepages occur, too, in other parts of the peninsula, between Bering Lake and Controller Bay, in the region west of Katalla, in the so-called "Nitchawak region," and in various other places. A strong flow of gas of unknown composition bubbles to the surface of the water at a number of places along the lower course of the Katalla River.

The first well in the Controller Bay region was drilled in the summer of 1901, but was not completed. The same company drilled another well in the summer of 1902, which yielded some petroleum at a depth of about 250 feet. At 360 feet below the surface a large flow of oil was encountered, and the well was at once capped and drilled deeper. The total depth is now reported to be 550 feet. Another company began work in the spring of 1903 in the same locality, but with not much success, though a little oil was brought up in the bailer from time to time. Fifteen wells have been drilled or were drilling in this region in September, 1904. During 1903 there was little commercial production of petroleum, notwithstanding the numerous surface indications. This should not, however, discourage the prospectors, as all indications point to large reservoirs of oil waiting to be tapped by the drill.

Cape Yaktag is situated about 75 miles east of Controller Bay. A strip of land from 5 to 10 miles in width lies between the coast and the Bering glacier. The coast affords no harbor protection for shipping of any kind. The ice-front of the glacier is marked by a line of hills parallel to the coast, drained by many short parallel streams. The oil fields extend eastward for about 25 miles from the mouth of the river Yaktag. The structure is said to be anticlinal, with axis parallel to and very near the shore line. There are said to be good seepages in several creeks in this belt, and the petroleum is regarded as similar in character to that of the Controller Bay field. No development work has been done, due to the difficulty of transporting machinery.

The Bering River coal field lies from 12 to 25 miles inland from Controller Bay; the coal area, as far as known, is restricted to the region north of Bering Lake and Bering River, though it is believed to exist in a much larger area. The coal is restricted to the rocks of the Kushtaka formation described above.

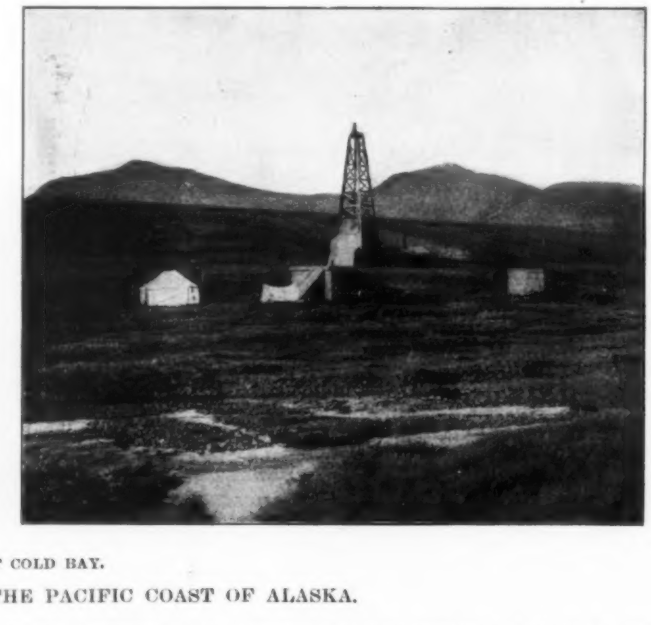
Several prospect openings and a well-constructed tunnel have been driven into the banks of Carbon Creek. The latter intersected two seams, the larger of which has a thickness of 8 feet of clean coal. The valley of Stillwater Creek and Lake Kushtaka has been shown to contain a great deal of valuable coal. Seams 15 to 16 feet in thickness and one of over 60 feet in thickness have been exposed, according to report, in that region. Numbers of valuable seams have been opened in the valley of Canyon Creek. In the opinion of the writer the seams now exposed in the valley of Shepherd Creek are the most promising.

The physical properties of the coal appear to be much alike in all the seams and in all parts of the field visited by the writer The coal resembles the harder bituminous coal of the East, but requires rather careful handling in shipping. The work which has been done in the development of this field so far is entirely pioneer development work. There is no local market for the coal, and this fact necessitates shipping for long distances. Water transportation is the only available means, and the harbors that could be used are at Controller Bay and Katalla Bay. The petroleum could be shipped from the same harbors without much trouble, as pipe-lines could be laid at a comparatively low cost.

The region of the Cook Inlet petroleum fields occupies the western shore of Cook Inlet for a distance of about 40 miles, extending inland a maximum distance of about 10 miles. Its coast includes the deep indentations of Chinitna, Enochkin, and Iliamna bays and the lesser ones of Oil and Dry bays. The region includes a high mountain range, a range of lower hills, and an intervening valley region. The lowlands are covered with dense vegetation, and consist of about half meadow and half forest, the latter mainly of fair spruce and hemlock. A wagon road has been built from the lower landing point of Enochkin Bay to the head of Oil Bay, and there are numbers of good cleared trails.

The rocks of this region consist of a zone of massive crystallines exposed in the Chigmit Mountains, a sedimentary formation of Jurassic age in a belt east of them, and a series of overlying agglomerates, shales, and bedded volcanic flows, which are exposed in the Tilted Hills. The formations lie in belts parallel to the coast. The relation of the sedimentaries to the crystallines is complex and obscure, but the remainder of the series is conformable nearly throughout, and is gently and simply folded.

The structure of this region consists of a broad, low, somewhat undulating anticline parallel to the shore of Cook Inlet and to the general line of the eastern front of the Chigmit Mountains, followed on the west by a narrow syncline, beyond which is the second, very closely folded, and probably faulted anticline. The dip in the broad easternmost anticline is moderate in amount and very regular, except on the crest of the fold, where it is undulating but not in excess of 10 deg.



OIL DERRICKS AT COLD BAY.

PETROLEUM AND COAL FIELDS OF THE PACIFIC COAST OF ALASKA.

The surface indications of petroleum in this region consist of seepages or oil springs and the so-called "gas springs." The center of the oil zone, which at present seems to be most promising, lies on a line extending from a point about a mile above the shore of Enochkin Bay to a point half a mile northwest of the beach at Oil Bay, thence through a third point two miles above the beach at Dry Bay to the north shore of Chinitna Bay. The oil sand would probably be found nearer the surface along this line than either to the southeast or the northwest. As regards the entire Enochkin Bay region, it is almost certain that the oil will be confined to the easternmost anticline.

Indications of petroleum were discovered in this region about fifty years ago, but the first well at Oil Bay was not begun until 1898. It has been drilled to a depth of somewhat over 1,000 feet. Since then a number of other wells have been sunk, resulting in more or less strong indications of oil. The shipment of petroleum from this field would probably be from Enochkin or Chinitna Bay, which are harbors affording safe anchorage to large vessels in all weather, as well as good wharf sites.

Cold Bay is situated on the south shore of the Alaska peninsula at the southwestern end of Shelikof Strait and opposite the west end of Kodiak Island. It may be reached by steamer from Seattle in about fifteen days, or from Bristol Bay by canoe and portage across the peninsula. Cold Bay, one of the best harbors of the rugged southern shore, is roughly triangular in shape, and contains a very large area of deep water. The surrounding country consists of an elevated upland with gently rounded or flat-topped hills. The higher peaks rise to an elevation of about 1,500 feet, but farther back from the coast in the central part of the peninsula are mountains, among them the volcano Peulik, 5,000 feet or more in height. The streams emptying into

Cold Bay and into the other bays in the vicinity are short and swift, carrying no very large amount of water. The northern slope, on the other hand, is drained by a comparatively small number of fairly large rivers, which have lakes at their headwaters or along their courses. Of these, Lake Becharof is one of the largest. The presence of these lakes and rivers affords an easy means of transportation throughout the region. Timber is entirely lacking, though the flat lowlands along the shores of Cold Bay are covered with deep grass, a vegetation characteristic of the greater part of the Alaska Peninsula.

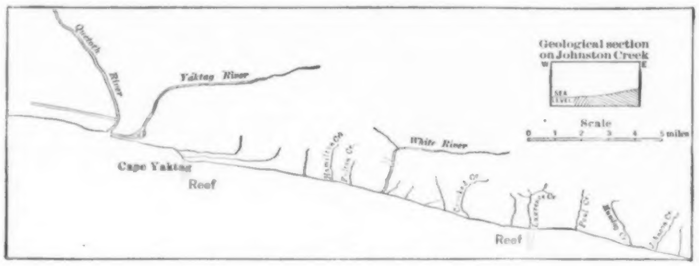
The rocks seen by the writer in the vicinity of Cold Bay consist of dark brown arkosic sandstone alternating with conglomerates, and a few thin limestones and dark shales, which break on the weathered surface with a conchoidal fracture. Fossils found here are believed to belong to the middle Jurassic period. The coarse crystalline rocks (granite, syenite, and rocks of similar texture) occur in a belt parallel to the length of the peninsula. They cross the lower end of Becharof and Naknek lakes, and possibly underlie the Cold Bay region. The Triassic rocks occur on Cape Kekurnoi at the eastern entrance to Cold Bay and on some of the capes and islands to the northeastward; they doubtless underlie the Jurassic throughout the region. The rocks in the vicinity of Cold Bay are very gently folded, the dips are low over wide areas, and the zones of steep dip are narrow and infrequent.

There are several seepages at the north end of the anticline near the oil wells. In all of them the flow of petroleum is large and constant. There is also a considerable flow of gas at one of these seepages. Other seepages are reported from various places along the crest of this same fold near the head of Dry Bay and elsewhere between that point and Kanata. There are said to be even more important seepages on the west shore of the south arm of Becharof Lake.

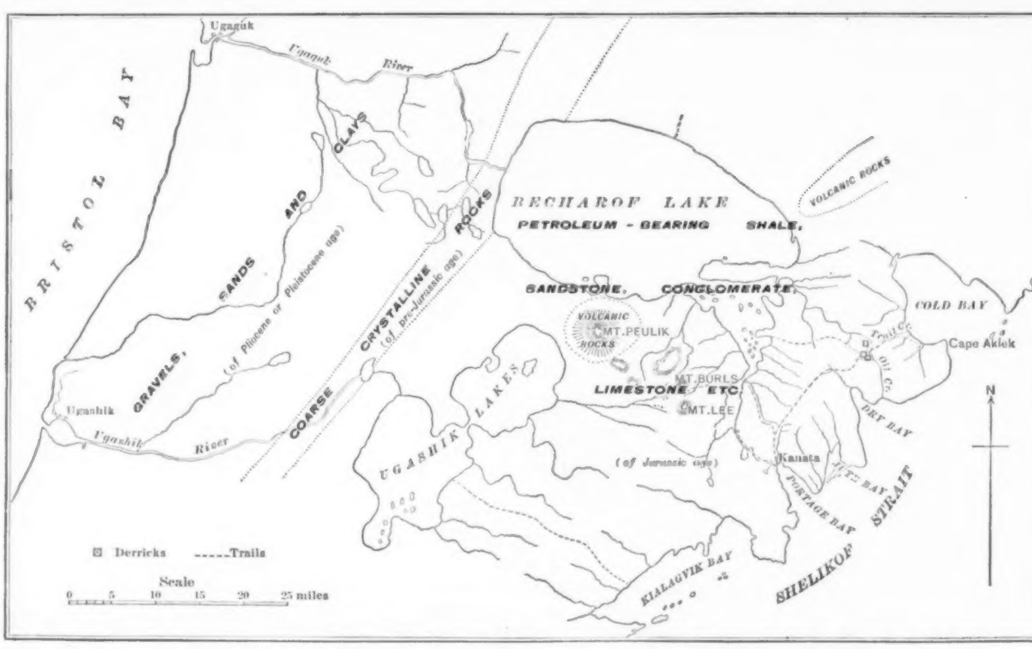
Three wells were begun in the summer of 1903. They are located about 5 miles from the landing on the west shore of Cold Bay, at an elevation of about 750 feet above tide, and about 9 miles from Becharof Lake; in one of these the drill is said to have penetrated several strata filled with thick residual oil having about the consistency of warm pitch. A strong continued flow of fresh water caused the abandonment of this well during the summer of 1904.

On some of the hillsides near the oil derricks are seepages of petroleum, where the oil has run down the hillside in the water courses, and collected at the bottom in peat bogs. Losing enough of its volatile constituents by evaporation to render it immobile, it remains there, impregnating the peat and forming over its surface a thick coating of black paraffine wax. The resulting fuel is of an extremely high caloric value, and has been used under the boilers in drilling operations.

Controller Bay petroleum is clearly a refining oil of the same general nature as the Pennsylvania product. That of the other Alaskan oil districts does not appear to be of quite so high a quality, but is nevertheless a refining oil.—From the Geological Survey Bulletin on the Petroleum Fields of the Pacific Coast of Alaska, with an Account of the Bering River Coal Deposits, by George C. Martin.



REGION OF THE CAPE YAKTAG OIL FIELDS.



THE COLD BAY OIL FIELDS—SOUTH SHORE OF THE ALASKA PENINSULA.

PETROLEUM AND COAL FIELDS OF THE PACIFIC COAST OF ALASKA.

THE COLORATION OF GLASS BY EXPOSURE TO LIGHT.

By Dr. Richard Lucas, in Umschau.

Ordinary window glass is often found, after several months' exposure to bright sunlight, to have undergone a change, which usually manifests itself as a faint violet coloration. In lettered show windows, from which the letters have been removed after such exposure, the images of the letters appear colorless on a violet ground.

Sir William Crookes recently showed the Royal Society two panes of glass colored deep violet by sunlight. Both came from altitudes of more than 1,300 feet, one from Chile, the other from Bolivia.

Now it is not only to be expected, *a priori*, but it has been proved by experiment, that sunlight is far more intense at such altitudes than at the sea level, and Schumann has found that the ultra-violet rays are absorbed by comparatively thin layers of air. It seems probable, therefore, that these rays are the chief agents in this coloration of glass and this view is confirmed by the experiments of Gehrke, who, at the recent scientific congress at Breslau, exhibited specimens of glass colored violet by forty-eight hours' exposure to the radiation of a mercury vapor lamp, which consists chiefly of ultra-violet rays.

But these are not the only rays that may produce this change in glass. Cathode rays, Roentgen rays, and the Becquerel rays emitted by radioactive substances effect the same result.

In the course of some experiments with aqueous solutions of radium bromide the writer found that the walls of the glass vessel above the surface of the liquid became deep violet, while below the surface, where the energy of the radiations was expended in electrolysis, the glass remained colorless. After the vessel had been emptied the level at which the liquid had stood was clearly marked by the boundary of the colored portion. The color is not superficial but extends throughout the glass.

In seeking the effective factor common to these various radiations we are led back to Hertz's discovery, in 1887, of the effect of ultra-violet rays in increasing the sparking distance between two metal balls and Wiedemann and Ebert's proof that the effect is confined to the cathode. In other words, ultra-violet rays generate cathode rays.

Now the Roentgen rays, which also ionize the air and increase its conductivity, are derivatives of the cathode rays.

The Becquerel, or radium rays, have been analyzed into three groups, the α, β, and γ-rays. The α rays are identical with Goldstein's canal rays, the β rays with the cathode rays, and the γ-rays with the Roentgen rays.

Pellini and Naccari's recent experiments on the action of the Becquerel rays upon glass show that the coloration is caused by the β and γ components, that is, cathode and Roentgen rays. Cathode rays, finally, are simply currents of swiftly-moving negatively-charged particles.

Evidently, then, all cases of the coloration of glass by radiations may be referred to a common cause and the phenomenon is an electro-chemical one, in which chemical changes are induced by electrical action.

The nature of the chemical change is not yet clearly known. The violet coloration is evidently derived from the manganese which is commonly added to glass to correct the yellow tint due to the presence of iron. For the sake of completeness it should be added that brown and other tints are sometimes developed by insolation, according to the composition of the glass.

Ladenburg attributes the violet coloration to manganic acid produced by the action of the ozone which is developed by the rays. But the coloration also takes place inside of a Roentgen tube which contains only an infinitesimal quantity of oxygen. It is possible, also, that the oxygen required to form manganic acid is derived from the ferric oxide in the glass.

The ultra-microscope has disposed of another apparent possibility, namely, that the violet unit may be a fog color, due to opaque particles distributed through the glass. The particles of gold to which gold ruby glass owes its color have been detected by this instrument, as have the particles (presumably metallic sodium) which produce the blue tint of crystals of common salt which have been exposed to cathode rays, but the ultra-microscope has failed to detect any separate particles in manganese glass.

When the tinted glass is heated to 500 deg. C. the color vanishes and the blue color of salt is also destroyed by exposure to very intense cathode rays, probably because of the heat which they develop.

[Translator's Note.—In the blue print photographic process a ferric is reduced to a ferrous salt by the action of light. If, as Dr. Lucas suggests, a similar change occurs in glass, the yellow tint due to the ferric comopund would be destroyed and the violet, or manganese tint, already present and added for the purposes of neutralizing the yellow, would become visible, modified only by the pale green of the ferrous compound formed. Whatever may become of the released oxygen, therefore, the reduction of the ferric salt would account for the violet coloration, and if such reduction occurs it appears not unlikely that yellow or red iron glass, free from manganese, would be found to be *bleached* by prolonged exposure to sunlight.]

A large proportion of the labor on farms is done by the farmer himself or his growing family. The inability to find steady employment for laborers is a very difficult problem. Ordinarily, men desire to work all the time and to use their energy to the best advantage. A farmer's family arrives at the productive age when the parent is between forty-five and sixty. The farm does not offer opportunity for the sons because the father still desires to maintain his activity. The farmer does not take the boy into his business to the same extent that other business men do. The result is that the sons must find employment elsewhere, and in the nature of the case can most conveniently find employment on salary. By the time the father is sixty-five to seventy years of age and feels the necessity of giving up the farm, the sons are engaged in other lines of effort which it is not practicable for them to leave. The result is that the farm declines with the declining years of the father and upon his death is sold or becomes a rented farm. Occasionally a parent solves the difficulty, and herein a distinct public responsibility rests on the individual farmer.

THE CONSTRUCTION OF THE VERTICAL SUN-DIAL.

I. INTRODUCTION.

THE fable runs that upon one occasion the turret clock was boastingly lauding its superiority over the sun-dial because it could tell the time even in bad weather, whereupon the company took sides, and the modest sun-dial retorted that whatever other accomplishments her most distinguished competitor, the turret clock, might possess, she nevertheless was always fifteen minutes slow. The fable points a moral that is worthy of our consideration. The sun-dial gives the "solar time," whereas the best of turrets furnishes us

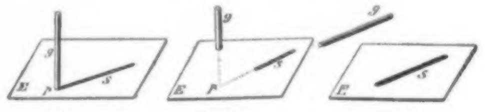


FIG. 1. FIG. 2. FIG. 3.

only with the mean or "civil time." These two times differ, first because of the inclination of the earth's axis to the ecliptic, and again because of the elliptical conformation of the earth's orbit; the alteration in the speed of the motion of the earth resulting therefrom, occurring four times a year, amounts in all to about a quarter of an hour. However, this does not prove unconditionally that the tower clock does not indicate the correct time.

The maker of a sun-dial must therefore from the outset make the best of this unavoidable deviation from the civil time. The difference between civil time and local time, on the contrary, as it exists since the introduction of the Central European time, may be taken into account, which we shall do below. In the beginning we accept as well known that the gnomon of the dial must be set up parallel with the earth's axis. Even then its shadow will vary in length according to the seasons of the year, but it falls nevertheless upon the same straight or right line at the same hour of the day, and upon this characteristic depends its efficiency. This variation in the length of the shadow cast by the gnomon may be profitably utilized, however, and the plane of the dial may be so arranged that the months of the year will be shown upon it as in a calendar. This, though, is an after-consideration. We must remark just here that such a dial does exist, and it may be seen on a house at No. 8 Dorngasse in Strasburg.

Waiving for the moment the consideration of the

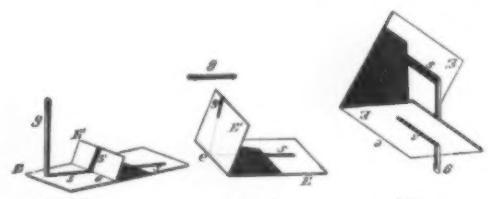


FIG. 4. FIG. 5. FIG. 6.

equality of time, we may assume that the sun describes a circular path in the heavens, the plane of which is perpendicular to the axis of the earth; that it completes its passage through this circular orbit in 24 hours at a uniform rate of speed, describing an arc of 15 degrees every hour.

We shall then bring up for consideration the following facts from the science of shadows:

1. The shadow (S, in Fig. 1) which a straight line, g, casts upon a plane surface, E, is rectilinear.

2. If a right line, g, cuts the plane, E, at a point, p, then the shadow, s, will also pass through p (see Figs. 1 and 2). If g be parallel to the plane, E, then its shadow will be parallel to it (see Fig. 3).

3. If a straight line, g (Figs. 4 and 5) cast a shadow, $S S'$, upon two intersecting planes, E and E', then the shadows, s and s', will melt each other at the line of intersection, e, of the two planes, E and E' (Figs. 4 and 5), or they will both be parallel to e (see Fig. 6).

These propositions must become self-evident upon viewing the figures named, said figures having been purposely exaggerated in order to make the results more conclusive. For the sake of clearness, however, the propositions 1 to 3 must be referred to their fundamental mathematical principles.

The shadow of any given point, P (Fig. 7), arises from the ability of such a point to intercept a ray of light falling upon it. In the prolongation of the ray

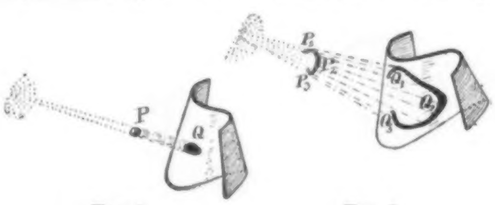


FIG. 7. FIG. 8.

of light, the so-called "ray of shadow," we therefore meet with no more light, but rather a space of utter darkness. If the "ray of shadow" fall upon any object as Q, then this point or assemblage of points, Q, remains dark and is therefore termed the shadow of P.

Let us now consider (Fig. 8) any irregular line, $P_1\ P_2\ P_3$, then the rays of shadow emanating from its points will form a cone of shadow of this line. If we assume the source of light to be infinitely distant, then this cone of shadow will become a cylinder. Wherever this cone of shadow intersects a plane, the shadow of the line, $P_1\ P_2\ P_3$, will be visible (compare $Q_1\ Q_2\ Q_3$ in Fig. 8). If the assemblage of points, $P_1\ P_2\ P_3$, form a right line, then the shadow cone will be a plane, the shadow plane of the right line, $P_1\ P_2$. If the surface upon which the shadow falls be also a plane surface,

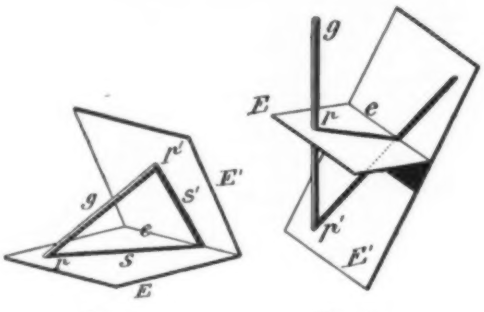


FIG. 9. FIG. 10.

E, then the shadow, s, will be straight, because the intersection of two planes is a right line. (Proposition 1.) Since now both g and s lie in the same plane, namely the shadow plane, they must either intersect each other or they remain parallel. This latter statement is made apparent in Fig. 3. If they meet at the point, p, then p is the point of intersection of g with E, for since p lies upon the line, s, it also lies in the plane, E. This is a confirmation of Proposition 2. Finally, if the surface upon which the shadow falls consist of two planes, E and E', having the line of intersection, e, then e and the shadow, $S S'$, comprise the complete intersecting system of three planes, viz., E, E', and the shadow plane. But three such right lines or surfaces are either parallel (Fig. 6) or they possess a common point of meeting, the point of intersection of the three planes. With this we have proven Proposition 3. From this we deduce at once a more important consequence. The shadow, s (Figs. 9 and 10) of the upright, g, upon the plane, E, is already known to us. It is furthermore known of a second plane, E', that it cuts the plane, E, at e, and that g also cuts E' in p. We may then immediately draw the shadow, S', of g upon E' thus: Produce s till it meets e, and from that point draw a straight line to p'. In this the shadow, s', of g lies on E. If all this be well understood, then, without further ado, the idea which leads up to the construction of a vertical sun-dial will become clear. In Fig. 11 let $V H$ be the gnomon of a sun-dial. We shall now imagine a horizontal plane to pass through the free point, H. This will intersect the face of the upright sun-dial at the horizontal line, $h\ v$, and the shadow of the style or gnomon will then fall from H in a straight line as far as the line of intersection, $h\ v$, where it will bend into the vertical plane and proceed in a straight line to V, the fixed point of the gnomon. Now, if we are in the position to draw a horizontal time scheme, we may derive a vertical

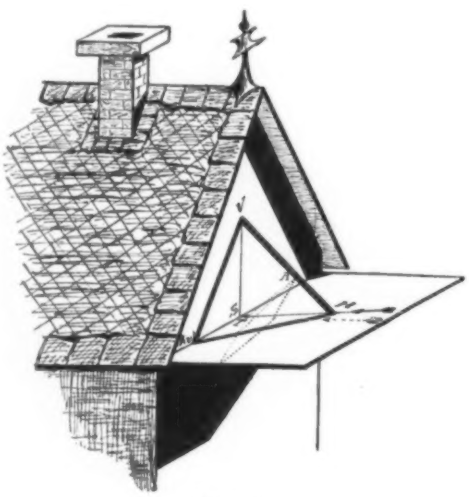


FIG. 11.

scheme directly from it by producing the hour lines till they meet the line of intersection, $h\ v$, and from the intersecting points connect them with V. Whether the two dials are exactly horizontal or vertical is not material for our observations. In the same manner we may construct the horizontal dial itself from a third dial, as this is usually done with the aid of the equatorial dial.

We have then two chief tasks to perform: First, the construction of an equatorial sun-dial, that is, a clock of which the marked face is arranged perpendicularly to a style or gnomon erected parallel with the equator. Secondly, the correct transfer to a sheet of paper of the surfaces or planes existing in space. The first of these tasks is generally well known, the second belongs to the domain of descriptive geometry, i. e., that part of geometry which pertains to the solution of phenomena of space by plane drawings.

II. THE EQUATORIAL SUN-DIAL.

If we imagine a plane to pass at once through the sun and the style or gnomon, this will be the shadow-casting plane of the gnomon. Now, since the sun moves in a circle perpendicular to the gnomon, the shadow plane will move with the same angular velocity that the sun describes in its circular path, that is, it will move 15 deg. an hour. The intersection of this

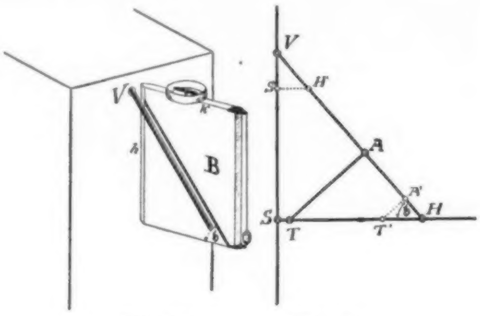
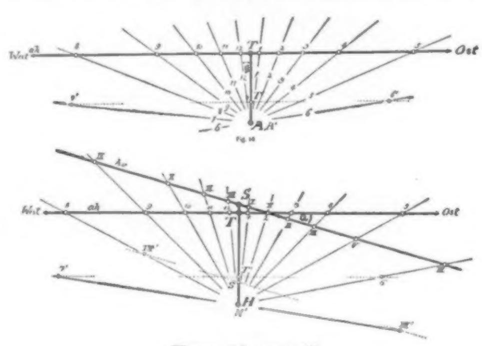


FIG. 12. FIG. 13.

plane with the face of the dial provides the shadow for the time being. But if the face be perpendicular to the gnomon, then it will be also perpendicular to all the shadows cast by it, from which we at once deduce that the shadows also advance 15 deg. every hour. Knowing this, we are in a position to mark out all the hour lines after we have obtained one of them.

To find such a starting line is by no means difficult. At solar midday the sun stands on the meridian. Its shadow is therefore the intersection of the dial plate with the plane of the meridian. We shall call this the noon line, and in the northern hemisphere it must of course be drawn toward the north. From this we easily get the line for 12 o'clock. Along the meridian of 15 deg. east of Greenwich we meet next the midday line, which is at the same time the 12 o'clock line for Central European time. For every 15 deg. of longitude we have a difference of one hour in local time, and an hour corresponds exactly to the movement of the shadow through 15 deg. of arc. Thus the angle between the 12 o'clock line and the noon line is exactly the deviation of the geographical longitude of the lo-



FIGS. 14 AND 15.

cality situated 15 deg. east of Greenwich. Let us indicate this angle by the letter m. We now lay off this angle west or east of the noon line, according as the place in question lies west or east of the fifteenth degree of longitude. Now, having established the 12 o'clock line, we lay out on both sides of it divisions radiating from the center, and separated from each other by an angle of 15 deg., and these are the hour lines; between them we may add the subdivisions for the half hours and quarters. In Figs. 14 and 19 $A\ T$ is the noon line. West of it is drawn a line at an angle to it of, in round numbers, 8 deg. The clock, or rather sun-dial, represented here is adjusted for a locality of 15 deg. — 8 deg. = 7 deg. east of Greenwich, or about the longitude of the city of Strasburg.

III. THE PLANE OF THE MERIDIAN.

In order to adjust the gnomon of the sun-dial correctly let us imagine the following procedure put into practice: Cut out a short board with perfectly square corners. Sharpen one of the long edges, h, by planing off its edges and upon the remaining squared side adjust a plumb-line as shown at B in Fig. 12. Upon the upper edge, also left square, attach a small compass, K. Now if we hold the board perfectly plumb and

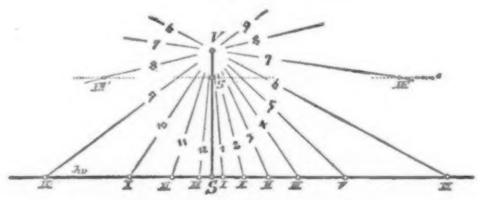


FIG. 16.

cause the needle of the compass to coincide with the line K of the upper end of the board, then the board will lie in the plane of the meridian. In this operation the declination must be taken into consideration —that is, the deviation of the needle from the true north-and-south line, which is indicated upon large ships' compasses or any larger compass by an arrow.

When the compass needle settles directly over this arrow the position of the board may be considered correct. We may now draw a straight line upon the board that shall form an angle, b, with the upper or lower edge of the board equal to the elevation of the pole, and this line will be parallel with the axis of the earth and from it we may adjust the gnomon of our sun-dial as we show in Fig. 12. If now we replace the board by an imaginary plane which we shall cause to pass through the gnomon we shall obtain, when we lay this plane out on paper, a figure equivalent to what we show in Fig. 13. This we call

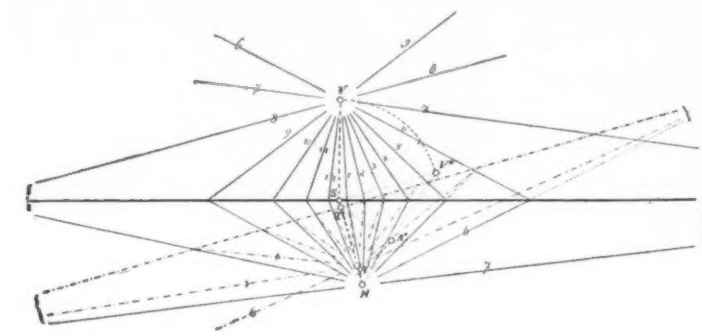


FIG. 17.

the M, or meridian plane. V is the fixed point of the gnomon and H its free end. $V S$ represents the edge h, of the board in Fig. 12, which forms the intersection of the vertical dial plate with the M-plane, in other words a vertical line. $H S$ is the intersection of the horizontal plane (Fig. 11) with the M-plane, thus falling perpendicularly, or at right angles, upon $V S$ at S. The angle at H is b (in the drawing that we show, it is about 48½ deg. or equal to the longitude of Strasburg). Let us select any point whatever upon the gnomon, say at A, and imagine an equatorial dial-face placed there; this will cut the M-plane along the line $A T$, which will be perpendicular to the gnomon and may intersect $H S$ at T. T may even fall upon S, but it is not compulsory that it should.

IV. THE THREE DIAL-PLATES.

In the following discussion we shall call the vertical plane in which the sun-dial we are building is to be situated the V-plane, the corresponding horizontal plane the H-plane, and finally, the equatorial plane the A-plane. We shall begin by imagining them entirely separated one from the other and transferred individually to paper, when A will appear like Fig. 14, H as shown in Fig. 15, and V according to Fig. 16. In each one we bring prominently to notice its intersection with the meridian plane; in Fig. 14 this is shown in the heavy line $A T$, in Fig. 15 at $H T S$, and in Fig. 16 at $V S$. The respective lengths of these lines correspond with the distances between the same letters in Fig. 13, since they are also laid off in the plane of said Fig. 13. That they should appear vertical in the figures before us is of no importance. For that matter, the planes A, H, and V may be projected upon the paper in any desired manner. (Compare Fig. 17, for example.) We now have to draw the intersections of the A and the V planes with the H-plane. In the first place as far as the line of intersection $a h$ of the planes H and A is concerned, it is obviously the east-and-west line; for, since A and H stand perpendicularly upon the M-plane, their intersection is also perpendicular to the M-plane, that is, it runs from east to west. The line $a h$ is accordingly purposely drawn perpendicular to the lines $A T$ and $H T$ in their respective Figs. 14 and 15. Secondly, as for the line $h v$, it is perpendicular to $V S$ in Fig. 16, because it is horizontal, and $V S$, as we have said before, is perpendicular.

In Fig. 15, on the contrary, $h v$ forms with the line $a h$ an angle a which corresponds with the deviation of the V-plane from the east-and-west line; this may be seen from the ground plan of the house upon which the clock is to be erected.

We have now demonstrated how the heavy lines and the double circled points of our figure are to be laid off from the length of the gnomon, the geographical latitude b and the angle a.

The further completion of the sun-dial is henceforth a matter of no difficulty. With the data given in the second chapter, we may now proceed to lay off the hour lines in the A-plane (Fig. 14). These lines intersect the $a h$ line in the points 8, 9, 10, etc. The dial laid off in the H-plane will cut this line in the same points.

We shall therefore transfer the divisions from Fig. 14 to Fig. 15 and in such a manner that the point T of the former falls upon the T of the latter, and then draw in the lines H 8, H 9, H 10, etc. These will cut the line $h v$ in the points $VIII$, IX, X, etc. Through these points the shadow rays of the V-dial must also pass. Therefore we apply the divisions of Fig. 15 to Fig. 16 so that the S of the former falls upon the S of the latter, and proceed to draw in the lines V, IX, V, X, etc. This being finished, the desired result is accomplished, viz., the construction of the V-dial, and it is now ready to be placed upon the front of the building.

Technically speaking, it must be remarked that some of the points of intersection fall without the limits of the drawing, as 7 and 6, VII and $VIII$. Since, however, the selection of the point A is arbitrary, for the benefit of such points we may move A closer to H, say at A', by the aid of which device we shall be able to draw in the 7 and 6 o'clock lines according to Fig. 15.

Furthermore, since the length of the gnomon is unrestricted we may imagine it for the time being cut off at H', whereby the point S will move up to S' and the VII and VIII o'clock lines that are wanting in Fig. 16 may now be drawn in.

V. $a = 0$.

If the V-plane runs exactly east and west, that is, the line of intersection $h v$ makes no angle with the line $a h$, then it is advisable to place the point T upon S, thus making A the nadir of the perpendicular let fall from S upon $V H$. As Fig. 15 will instantly show, the lines $a h$ and $h v$ will now fall one upon the other,

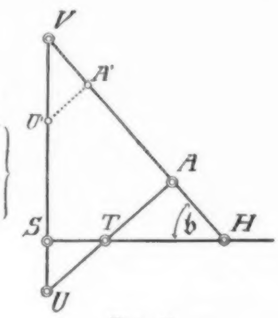


FIG. 18.

so that the divisions used in Fig. 14 may be applied directly to Fig. 16. This simple case must be regarded as generally known.

VI. HOW TO AVOID THE TRANSFER OF THE VARIOUS DIVISIONS.

If we place the three planes A, H, and V in the plane of the drawing so that H coincides with A as well as with V along the lines $h a$ and $h v$, we shall no further need to transfer the divisions of these lines from one to the other.

To those who are conversant with the rudiments of descriptive geometry this method will be familiar. Through the crossing and recrossing of the different systems of lines (Fig. 17) we admit the drawing loses in clearness; nevertheless it can be produced much quicker and with a greater degree of exactness, because the transfer of the points consumes time and is always open to small errors. In Fig. 17 the M-plane is joined to the H-plane along the line $S H$, and when

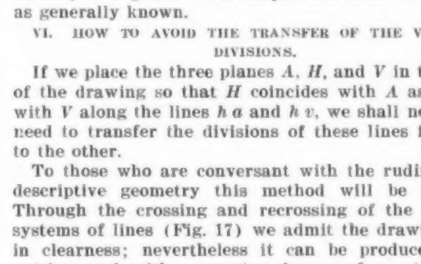


FIG. 21.

revolved to the right, lies as shown at $S H V^* A^*$. The lengths $S V$ and $A T$ are present in duplicate, as the arcs $V V^*$ and $A A^*$ indicate.

In this special case the transfer may not be completely avoided.

VII. DIRECT TRANSFER OF THE A-PLANE TO THE V-PLANE.

The question may be pertinently put whether or not the H-plane may be eliminated altogether, since the A-plane may be brought to intersect the V-plane directly. The work of drawing it may indeed be saved, but in its stead the mental work is considerably greater. We shall begin the construction again as we did in Chapter IV. In Fig. 18 we offer another drawing of the M-plane, but in this instance we shall select the point A so that T shall fall upon $S H$ somewhat farther removed from S than heretofore. By prolonging $A T$ it will meet the prolongation of $V S$ at a point, U, which is at once in the V-plane because it

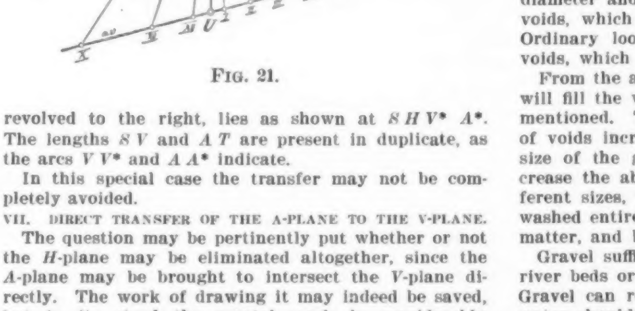


FIG. 19.

lies on $V S$ in the A-plane, because it lies on $A T$, and from the nature of the construction it is also in the M-plane.

We shall now start Figs. 19, 20, and 21 in the same way as we did those numbered 14, 15, and 16—first by drawing $a h$ perpendicular to $A T$ (Fig. 19), $a h$ perpendicular to $H T$, and $h v$ turned by the value of the angle a toward $a h$ through S (Fig. 20), finally by laying out $h v$ perpendicular to $S V$ (Fig. 21).

The lines $A T$, $H T$, $H S$, and $V S$ are all of the same length, as given in Fig. 18. If we regard Fig. 20, we see that $h v$ and $a h$ intersect each other in a point, P. This point lies, therefore, in the A, the H, and the V planes, and is at the same time a point in the $a v$ line, in which the A and V planes intersect. Upon this line we have already met the point U which we may transfer to Figs. 19 and 21. P may also be transferred to Fig. 19 by making $T P$ equal to the distance $T P$ in Fig. 20. Finally, we carry P into Fig. 21 by making $S P$ equal to the distance between the same two letters in Fig. 19. The line $U P$ represents in both Figs. 19 and 21 the line of intersection of the A and V planes. Since both these planes are connected along this line, it furnishes a proof of careful drafting, since $P U$ in both figures must be of the same length. Now when we draw in the A-dial and transfer its intersection with $P U$ to Fig. 21, we obtain immediately the desired vertical or V-dial and Fig. 20 remains without a dial, which was to be proved.

At the first blush this construction, as far as the drafting is concerned, appears very simple; it demands, on the contrary, considerable contemplation. In the form given here this construction is burdened with the disadvantage that the point P in Fig. 20 cannot be determined very exactly, for, in general, the right lines $h v$ and $a h$ will intersect each other flatly. An auxiliary construction is therefore advanced, but I must forego its proof. Let a perpendicular be drawn from H to $h v$ in Fig. 20. It will fall upon $h v$ at X and upon $a h$ at Y. We shall now carry these points into Figs. 21 and 19, then draw $a v$ perpendicular to $A Y$ in Fig. 19 and perpendicular to $V X$ in Fig. 21. The construction by means of the point P may then be used as a method of proving the correctness of the drawing.—Prof. Dr. Gerhard Hessenberg in the Deutsche Uhrmacher-Zeitung.

PROPORTIONS AND CHARACTER OF SAND AND GRAVEL TO USE IN CONCRETE.*

THE terms gravel and sand are a trifle indefinite and obscure. Sand, the grains of which are above a certain size, is called gravel, and there is no distinct line of demarkation between these two, one gradually shading into the other. For convenience we will say that all of the mixture which will pass through a No. 10 sieve is sand, while that which will not shall be called gravel.

The relative proportions of sand and gravel in concrete can only be fixed after careful tests of the material to be used. The writer's experience has been that gravel taken from different sources varies so much in size, that the proportion of sand to be added to make a good concrete would have to be determined in each instance. It would, therefore, appear to be impossible to make a definite specification that would cover the proportion of sand and gravel taken from different localities. In order to obtain the correct proportions to be used, the material in question should be screened, separating gravel from the sand, and the proportions of voids determined in each.

Good authorities state that loose gravel of ¾-inch diameter and under contains about 33 1-3 per cent of voids, which is reduced to 21 per cent by ramming. Ordinary loose sand contains about 38 per cent of voids, which is reduced to 21 per cent by ramming.

From the above it can be seen that one part of sand will fill the voids in three parts of gravel of the size mentioned. That is a mixture of 1:3. The per cent of voids increases somewhat with an increase in the size of the gravel, which would correspondingly decrease the above ratio. The gravel should be of different sizes, varying from coarse to fine, screened or washed entirely free from clay, loam, or other foreign matter, and be free from scale, slime or humus.

Gravel sufficiently clean can often be obtained from river beds or gravel bars, but rarely in gravel banks. Gravel can readily be cleaned by sluicing. Sufficient water should be used to carry away all objectionable matter, including fine sand. By using a good sluicing plant, the writer has washed out an excellent quality of gravel from banks containing a large percentage of clay.

The sand should be clean and sharp—preferably coarse and fine mixed—and entirely free from all foreign matter. Several authorities cite laboratory ex-

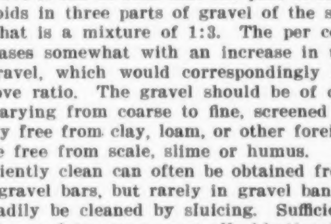


FIG. 20

periments to prove that a percentage of loam is not objectionable. However, the writer would not favor using other than clean sand in actual work.

During the past three years we have used, approximately, the following proportions with satisfactory results: For concrete in arches and girders, cement 1 measure, sand 1½ measures, gravel 4½ measures. In piers and abutments, cement 1 measure,

* J. H. Marsh in the Iowa Engineer.

sand 2 measures, gravel 6 measures. In spandrels and retaining walls, cement 1 measure, sand 2 measures, gravel 5 measures. For copings and parapet walls, cement 1 measure, coarse and fine sand mixed 3 measures. The work has shown no surface cracks, or spider-webs. The writer's experience would indicate that more cement is required in gravel concrete than in same volume when broken stone is used. We believe that 10 per cent is about the amount of extra cement that should be used in gravel concrete over and above that required with broken stone.

There is no question in the writer's mind as to the sufficiency of gravel concrete. In every instance where we have used it, we have found it to compare favorably with concrete made of broken stone. The gravel concrete is denser, and requires less ramming. We have built several concrete-steel girder bridges, of spans varying in length from 8 to 25 feet. In these we have used gravel and sand concrete, with gratifying results. The mixtures have been as specified above, and we see no good reason why properly-proportioned gravel and sand concrete could not be used in constructing arches of any length desired.

GLASS PAVING AND BUILDING BRICKS.

On April 15, 1904, the Department of State, at the request of the Secretary of Commerce and Labor, mailed a circular to the consular officers of the United States in Europe, instructing them to obtain information in regard to the manufacture of paving bricks from glass, the material used in the manufacture of such bricks, and their value for the purpose named; also whether bricks of this character are utilized for building purposes, and if so, with what success.

The following reports are the replies to the circular, covering consular districts where the bricks are manufactured or in use. The replies for all other portions of Europe state that glass bricks are neither manufactured nor in use in the respective countries or consulates.

Catalogues and prospectuses which accompanied many of these reports are on file in the Bureau of Statistics, Department of Commerce and Labor, where they may be consulted by interested persons.

FRANCE.

Artificial stone made from glass is manufactured in France under the Garchey patents, which are owned by the "Société Anonyme la Pierre de Verre Garchey," a limited liability corporation with a capital of $115,800, formed in 1900 for a period of ninety-nine years from January 1 of that year. Its offices are at No. 4 Rue Charras, Paris. Patents for the Garchey process have been obtained in most of the countries of Europe and their colonies, and in North and South America.

The principal French companies which manufacture the Garchey artificial stone are the "Carmausienne," with head offices at Toulouse and works at Bousquet d'Orb, in the Department of Hérault; "La Société parisienne d'Exploitation des Procédés Ceramiques Garchey," whose offices are at Lyon and whose factories are at Creil, Department of Oise; and Demi-Lune, near Lyon, Department of Rhône. The Garchey stone is also made in Spain, Germany, and Belgium.

Old glass obtained from broken bottles, window panes, etc., is used in the manufacture of products such as paving bricks, common tiles, etc., where uniformity of texture and color are not necessary. For the higher grades, glass is first made from sand of suitable quality, carbonate of lime, sulphate of soda, and potash, the proportion being about 5 of sand, 4 of lime, and 1 of alkali. After being cooled slightly the glass is granulated by being thrown into cold water. The granules are put into refractory molds and again heated to a temperature below complete fusion until they become plastic. The molds are then withdrawn from the furnace, placed under a hydraulic press, and subjected to a pressure necessary to form the plastic material into the desired shapes. After being trimmed the molds are passed through the cooling process in ovens specially constructed for the purpose.

In the two operations of heating and reheating the cost of coal necessary to obtain the required temperatures is one of the factors which tend to make the production of Garchey stone expensive. I have been informed that the inventor has discovered another process for making the stone from glass in one heating by which the cost is materially reduced.

The Garchey company in Paris claims that the cost of production under the old process varies from 86.85 cents to $1.06 the square meter (10.76 square feet), according to where it is manufactured, the cost of labor, price of coal, etc., or an average of 96.5 cents per square meter. The company bases its claim upon the results which have been actually obtained in the Spanish, Belgian, and French factories.

The Garchey stone is manufactured in a variety of forms for paving streets, sidewalks, and gutters and for the uses for which porcelain and other tiles are employed, as tiling the walls and floors of bathrooms, operating rooms in hospitals, waiting rooms and staircases of railroad stations, etc. As the Garchey stone has the chemical and physical qualities of glass it is not readily attacked by chemical products, so that it can be used in factories and laboratories where acids and other chemicals are employed, and being impermeable to moisture can be used in cellars and other places where there is much humidity. The stone is also molded in ornamental forms and can be made according to the drawings of architects and interior designers for decorative purposes in drawing rooms, offices, etc. To my knowledge, the Garchey bricks are not used in the construction of buildings, owing principally to their cost in comparison with other materials.

In the manufacturers' catalogues many shapes and styles are illustrated. The following are the prices of tiles, bricks, etc., mostly used:

Plain, smooth, or fluted tiles, 7.87 inches square, or 13 inches square, about three-fourths of an inch thick, used for tiling the sides of kitchens, dining rooms, corridors, bathrooms, etc., or flagging sidewalks, stables, passages, etc., 19 cents per square foot.

Bricks, roughed or fluted, 5½ inches square, 1.57 inches thick, also 7.87 inches long, 3.54 inches wide, 1.79 inches thick, for paving purposes, 27 cents per square foot.

For borders of sidewalks, gutters, or for staircases: Step, fluted or roughened, 19.7 inches long, 6.3 inches wide, 21.2 cents each; riser, 19.7 inches long, 7.87 inches wide, 26 cents each; bottom of gutter, same dimensions, 28.95 cents each.

For a highly ornamental tile 19.7 inches long, 13 inches wide, 63.7 cents each.

The bricks, squares, and tiles can be made in various colors—white, green, white and black, pink, yellow, etc.

For large orders, or to architects and dealers, the manufacturers allow a discount of from 20 to 25 per cent from the catalogue prices. The manufacturers claim that although the first cost of the Garchey products may be higher than other materials used for the same purpose, yet, owing to their wearing qualities, they are more economical.

The Garchey tiles are in use for tiling the walls, floors, and staircases in several of the stations of the Metropolitan Railway of Paris. In reference to the results obtained, one of the principal officers of the railway company writes me:

"Owing to the extreme hardness of these tiles (Garchey), they are not easy to cut, so it is difficult to place them in position or to redress them when they are worn. The smooth tiles become slippery, but with those that are roughened satisfactory results have been obtained. Smooth tiles are used on Line No. 1 and rough tiles on Line No. 2, the usual dimensions being 7.87 inches square and about three-fourths of an inch thick. For walls the Garchey tiles present an attractive appearance, and stand the wear and tear unusually well, but as the tiles can neither be cut nor drilled, except with great difficulty, it is not easy to hang pictures or advertisements. For the staircases it has been found that the tiles become polished rapidly, which makes them slippery when wet."

In several of the large cities of France experiments have been made with the bricks for paving purposes. At the present time the Rues Tronchet and Crimée in Paris are paved with the Garchey bricks. In reference to the experiment being made by the city of Paris, the chief of the highway department writes me as follows:

"The Société de Pierre de Verre Garchey was authorized to make a trial of its paving bricks made from glass in the Rues Tronchet and Crimée. The foundation for the paving is composed of a layer of concrete 5.9 inches thick, made in the proportion of 551 pounds of cement, 17.7 cubic feet of sand, and 35.3 cubic feet of small stones, and a layer of Portland cement 0.4 inch thick. The bricks measure 7.87 inches long, 3.74 inches wide, and 1.78 inches thick. They were laid directly on the foundation in rows perpendicular to the border, with a space between them of 0.2 inch, the space being kept by a wooden template of that thickness. The mortar used was mixed in the proportion of 1,322.8 pounds of Portland cement to 35.3 cubic feet of sand. Four days after the paving was finished the streets were open to traffic.

"Up to the present time the paving, without having given bad results, does not appear to be wearing as well as that made of natural stone. It has been noticed that alongside of the tramway rails the paving shows signs of deterioration. It is somewhat expensive to keep the streets in good repair. The thinness of the bricks renders them fragile, and being laid directly on a foundation of concrete they are more liable to break while their sonorousness is increased. It is probable, if the bricks were 4 inches thick and laid like the natural stone blocks on a foundation of sand, they would have given much better results. At the present time the city of Paris has no intention of substituting artificial paving blocks for those made of natural stone, nor in the future, unless it may be clearly demonstrated that it would be a decided economy to do so.

"To resume, the condition of the paving in the streets above mentioned is not such as to render it necessary to stop the experiment and remove the bricks, and it would be better to await the expiration of the three years, the period required for all similar trials, to determine the exact results."

In 1897, at the request of Mr. Garchey, the inventor of the process, tests of artificial stone, in comparison with other stones and materials used in construction, were made in the laboratory of the National School of Roads and Bridges at Paris. The main objects of the experiments were to determine the crushing strains the materials would bear and the effects of frost, concussion, and wear and tear. The results of the tests may be summed up as follows:

1. The Garchey artificial stone resisted a pressure of 28,774 pounds per square inch, while granite only stood a pressure of 9,245 pounds per square inch.

2. Influence of frost: The Garchey stone was immersed in refrigerating mixtures by which a temperature of 20 deg. below zero C. was obtained without any damage to the stone. Afterward it resisted a crushing pressure of 28,845 pounds per square inch.

3. Wear from friction: The friction was obtained by holding the material to be tested to the face of an emery wheel at a constant pressure of 3½ pounds per square inch, the wheel revolving at the rate of 1,777 feet in one minute. The Garchey stone was classed No. 5 in a list of 27 other materials which were subjected to the same test. The wear of the Garchey stone was 0.45 inch after 4,000 revolutions of the wheel.

4. Resistance to shock: It required on an average 22 blows of a pavior weighing 9¼ pounds falling a distance of 3.28 feet to break the Garchey stone, and 3 blows to make the first crack, while other materials ordinarily used for paving were broken in 19 blows.

The manufacture of bricks and tiles from glass in France can not be said to have met with unqualified success. It is the opinion of several persons with whom I have conversed that this is due not to industrial value of the products, but more to the fact that the process has not been sufficiently exploited.—A. M. Thackara, Consul, Havre, France.

Grenoble.

About a year ago paving bricks of pure crystal glass, based on scientific principles for the diffusion of natural light by radiation, made their appearance on the markets of France, and repeated tests and trials having fully demonstrated their value, they began to find favor with the general public and are being employed in increasing proportions by builders and contractors.

In Grenoble several buildings have already been provided with them, and from personal observation they appear to answer admirably the purpose for which they are intended, namely, the better lighting of cellars, underground rooms, dark corners, etc., by the radiation of natural light.

The following firms are engaged in the manufacture of these bricks: The Luxefer Prism Co., 9 Cours de la Liberté, Lyon; the St. Gobain, Chauny & Cirey Co., 9 rue St. Cécile, Paris, and Messrs. Palon & Royer, 76 avenue de la République, Paris.

I inclose the prospectus of Messrs. Palon & Royer, who are the sole agents and concessionnaires of the Mombel luminous bricks, in which will be found ample details concerning the different varieties manufactured, their sizes and prices, and the application for which each kind is adapted.—T. W. Murton, Vice and Deputy Consul, Genoble, France.

Lyon.*

Early in October, 1898, a paving company of this city began laying on the rue de la République a piece of pavement of ceramo-crystal, ceramic stone, or devitrified glass. During November and December, 1898, and thus far in January, 1899, this pavement has been driven over during all hours of the day and night. It has stood as hard usage as any pavement could be subjected to during that time, and is still in an admirable state of preservation. The glass, or ceramic stone, pavement is laid in the form of blocks 8 inches square, each block containing 16 parts in the form of checkers. These blocks are so closely fitted together that water can not pass between them, and the whole pavement looks like one large checkerboard. Like all thoroughfares in France, the roadbed slopes gently to the walk on each side. Some of the edges of the checkers have been broken off during their three months' service. I counted some twenty of them that have been slightly chipped on the edges. It is contended, and I think with justice, that this does not argue against the value of the material as a pavement, and that any kind of stone would have suffered just as much or more in the same time.

I visited the Ceramo-Crystal Manufacturing Company's works recently, at the suburban village of Demi-Lune, about 6 miles from Lyon. The factories cover nearly 8,000 square yards of ground. Work is now stopped in them while additions are being made to the buildings in the shape of second stories. In the yards are many tons of broken bottles, which the superintendent told me was their "raw material." On the four sides of a large brick smokestack are specimens of ceramo-crystal for buildings and interior decoration, some of the pieces as smooth as highly-polished marble, others rough like cut stone, and still others having a surface like common brick.

The advantages attributed to this ceramo-crystal by the manufacturers are: As a pavement, it has greater resistance than stone; it is a poor conductor of cold, and ice will not form upon it readily; dirt will not accumulate upon it as easily as upon stone, and it will not retain microbes; it is more durable than stone and just as cheap.

The Central Architectural Society of France made a report recently on this ceramic stone, of which I give a brief synopsis. An officer of the society reported that he had examined a square, suitable as a pavement or floor for a stable, courtyard, or factory; a block imitating polished marble; a block imitating mosaic, and a panel with molding and ornamentation. He said:

"From the various forms in which this material is presented its use can be readily determined for both practical and decorative purposes. On careful examination it is found that the Garchey ceramic stone is nothing but glass brought to a special molecular condition. In a certain sense it constitutes a new substance which resembles flagstone, granite, or marble. The manufacturer assures us that with this material he can copy any model that is presented. The product

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is obtained from broken glass heated to a temperature of 1,250 deg. and compressed in matrices by hydraulic force. The physical transformation of glass is due to devitrification under the Garchey process. The phenomenon of devitrification produces a sort of dissolution more apparent than real; for, upon chemical analysis, the devitrified glass preserves the identical composition of natural glass. It may be said, then, that devitrified glass possesses all the intrinsic qualities (physical and chemical) of glass except the transparency, while taking on an entirely different aspect. Furthermore, glass treated under this new method is made to resist crushing, frost, and heavy shocks, and to stand usage."

The subject is being discussed in the press and is receiving general consideration. An elaborate and exhaustive article in the Revue des Deux Mondes for November, 1898, treated it under the heading of "A Glass House," the writer asserting that a large house constructed entirely of glass would be an attractive feature of the coming world's exposition in 1900. He said that glass could be used for tubes, pipes, vats, tiles, smokestacks for factories, and for buildings. Double glass walls in a house would admit of the circulation between them of cold or warm air, thus regulating the temperature. "As to the resistance of such a structure, it would certainly be equal to that of the most solid houses of the day, . . . and it is lighter and less expensive than brick." "The Garchey glass stone had hardly come into existence before a method of using it, both simple and inexpensive, was revealed by the device of the American inventor Golding."

The glass house, or the luminous palace, which it has been decided to build on the grounds of the 1900 exposition, parts of which are now being constructed, is thus described by the writer last quoted:

"The principal façade, in the form of an immense portico, its roof surmounted with spires and with a winged statue representing Light, will be supported by heavy columns. The ground floor, reached by a double flight of stairs, will be used as a great exposition room. To the right and left will be large glass basins, overhung by grottoes of glass. In the interior of the hall will be five large openings, in which will be represented the five divisions of the globe."—John C. Covert, Consul, Lyon, France.

Nice.

The manufacture of glass paving bricks is not carried on in this district, and no bricks of this character are utilized for building purposes. Some years ago the municipality authorized an individual representing a manufacturer to pave with glass bricks a piece of the principal business thoroughfare, having a surface of about 1,000 square feet. It would appear that the experiment did not satisfy the authorities, for the piece of pavement was removed some months afterward. I remember seeing the bricks laid, and it struck me that the work was being very hastily and superficially done, and I noticed shortly afterward that the bricks had moved.—Harold S. Van Buren, Consul, Nice, France.

Paris.

The use of glass in the manufacture of blocks has been discussed for some years, and the new glass stone made by the Garchey Company seems to be the most improved kind yet patented or invented. It is glass devitrified by a special process, and offers a resistance of about three times that of granite. The atmosphere seems to have no effect upon it. It is claimed by the makers, the Compagnie de la Pierre de Verre Garchey, 4 Rue Charras, Paris (with branch factories in England, Belgium, Germany, and Russia), that it is harder than St. Raphael porphyry, and twice as hard as Comblanchien stone. It is also said to be capable of resisting an electric current of 60,000 volts, thus making it an excellent insulator by reason of its great resistance to high electrical tensions, to crushing, and to impact.

The process is patented, but appears to be simple, viz.: The glass is devitrified, put into molds, which are placed under hydraulic pressure and the block allowed to become hard. I inclose a copy of the company's catalogue, showing sizes of blocks, shapes, combinations, etc. Mr. Cheswright, of 29 Rue Mogador, Paris, who is interested in the patent, states that he will be pleased to give information as to rights of manufacture, etc., to any American firms writing to him direct.

There is also a hollow brick made of glass by the Société des Verreries de Dorignies, Nord, France, of which I send two or three samples; also a certain catalogue marked Exhibit 2. Mr. L. Viennot, 9 Boulevard de Denain, is the agent in Paris, but it is preferable to communicate direct with the company at Dorignies, Nord, France. Their bricks are hollow, but in different shapes and combination, and are suited for the construction of party walls, conservatories, etc.

I also inclose price list of perforated glass blocks made by Appert Frères, 34 Rue des Chasses, Clichy, Seine. These are suited for tops of windows, roofs, etc., for hospitals, barracks, factories, and kitchens.—John K. Gowdy, Consul-General, Paris, France.

St. Etienne.

Some years ago a plant was put up in this city for making bricks with glass as a base, but was closed in a very short time, the product finding no market. No other attempts in this department or in the others comprising this district have been undertaken. Bricks made from pure glass are almost unknown here. Some shops and hotels are furnished with floors or patches of floors made of glass, but no glass bricks are used in the streets in lieu of the ordinary stone. For building purposes no experiments have been made with such material. Glass tiles for sky and floor lights are coming into favor with architects. They are made of very transparent glass and cost 77 cents each, their usual dimensions being 16 by 10 inches. These tiles are chiefly manufactured at Passavant (Häute Sâone) and at Ecuisses (Sâone et Loire), while the glass flooring comes from St. Gobin, near Paris. The use of bricks or tiles is very limited in the district, although on the increase as compared with former years.—Hilary S. Brunot, Consul, St. Etienne, France.

GERMANY.

Glass Paving Bricks.—So far as can be ascertained, no glass paving bricks proper have been made or even tested in this district under such conditions as to afford a basis for rational conclusion as to their permanence, their cost as compared with other paving material, or their general desirability for that purpose. The editor of the Glas Industrie, the central organ of the German glass and ceramic industries, states in reply to an inquiry, that Lyon, France, is the only city known to him in which glass paving bricks have been most thoroughly and systematically tested, but the exact results of such tests are unknown here. Translucent glass tiles 5 or 6 inches square by 1 inch in thickness, are used for paving walks over cellars and subterranean vaults, engine rooms, and other places where more or less light is required to pass through the pavement, but this is a branch of the subject somewhat aside from the scope of the inquiry. No official or technical experiments appear to have been made in Berlin with glass blocks for paving streets and roadways.

Glass Bricks for Building Purposes.—There are, however, three firms in eastern Germany, viz., the Glashüttenwerke Adlerhütten at Penzig, near Görlitz, Silesia, the Actiengesellschaft für Glasindustrie in Dresden, and Gebrüder Streit, of Berlin, whose factory is in Silesia, all of whom make bricks of glass, not for paving, but for building purposes, in which the blocks, more or less translucent, are laid up in walls like bricks of ordinary character. At the international exposition of fire-extinguishing and fire-preventing devices, held in Berlin in 1901, the second of these companies exhibited a small châlet or villa, the walls of which were built of such bricks in several shades of dark green and blue, which attracted attention as a novelty. The avowed purpose of the exhibit was to demonstrate the merits of such material for resisting fire, and in this respect the tests, so far as can be ascertained, resulted satisfactorily.

Messrs. Streit manufacture in two shades—white and green—glass bricks which are especially adapted to the construction of walls and buildings where light, cleanliness, and neatness of appearance are specially desired. They are made in two sizes, both 2 inches thick, 2¾ inches wide, and 5 and 10 inches long, respectively, the short brick being half the length of the full-sized one. The edges are made with flanges which fit into countersunk recesses, so that the bricks may be laid, with very little cement, into air-tight and very firm, although thin, walls, and have a special fitness for many purposes, although their fire resistance is of course limited to the melting temperature of glass. They cost, by the list, 11 cents each for the large and 9 cents each for the small size, from both of which list prices there is a discount of 35 per cent for quantities exceeding 1,000.—Frank H. Mason, Consul-General, Berlin, Germany.

Dresden.

Paving bricks from glass are manufactured by the Glashüttenwerke Adlerhütten Actiengesellschaft, at Penzig, Silesia, Germany, about one hour's ride by train from Dresden. This firm owns and works the German patent No. 91,203, issued to Louis A. Garchey, of Paris, France, on March 21, 1896, the claims of which read as follows:

"1. A process for the manufacture of objects from devitrified glass, consisting in bringing about devitrification already in the raw mass before forming the object.

"2. A mode of carrying out the process, consisting in starting the devitrification of the raw mass in a heating furnace and finishing it in a melting furnace."

The product is known as "keramo," and is successfully used as a covering for floors of railroad stations, warehouses, engine rooms, stables, and for sidewalks, staircases, etc. It surpasses in point of hardness and wearing quality the very best Swedish granite. The bricks, or rather plates—for they average only 1 inch in thickness—are each about 8 inches square, and are laid out on cement mortar in the manner of the "Mettlacher plates." The power of resistance against pressure and frost is proved, for plates in the natural state stood a pressure of 4,050 pounds per square centimeter (0.155 square inch), and plates, after a frost test, stood a pressure of 4,060 pounds per square centimeter. Keramo plates are absolutely acid proof. In the adhesion test the resistance equaled 32 pounds per square centimeter. For tearing loose an 8-inch square plate laid out in cement a pulling force of over 12,500 pounds was required.

The prices for 25 plates (each 8 inches square) to the square meter, f. o. b. works, are $2.50 first quality and $1.80 for seconds. The weight of the square meter is about 100 pounds.

Building Bricks from Glass.—The same firm manufactures glass bricks for building purposes (system "Falconnier," patented). The bricks were exhibited at the Chicago Exposition in 1893 and received first awards. I remember the glass-brick pavilion in front of the horticultural building and the interest it aroused at the time. The bricks are made of blown glass, and owing to their hollow, closed form, are excellent temperature and noise insulators, and do not sweat or freeze. They are cemented together with mortar made of three parts sand, one part Portland cement, and enough white lime to render the mixture easily workable. These bricks are manufactured in various sizes, shapes, and colors, and average from 3½ to 16 cents each.

A recent patented improvement consists in the application of a wire mantle. The price of the bricks is thereby only slightly raised, while the stability is greatly enhanced. The wire-mantled bricks are set up like ordinary bricks, with hardly any breakage.

For ventilation of glass-brick buildings, a special ventilator is constructed, of which a number can readily be inserted in any desirable location, as they conform exactly to the shape of the bricks. These ventilator bricks are sold at 50 cents and 75 cents each, according to execution.—Charles L. Cole, Consul-General, Dresden, Germany.

Hamburg.

Glass bricks are not used in Hamburg for paving, but are occasionally utilized for building purposes, and with satisfactory results. In place of windows they are used to admit light in walls which, according to the police building regulations, are required to be fireproof and windowless. In addition to admitting light to dark hallways, rooms, etc., they possess the same strength as ordinary clay bricks. The hollow, so-called glass stones of the "Falconnier" system, which are made of blown glass in all colors and various shapes, are mostly used. They are also utilized in walls in yards and in partitions in the interior of houses, salesrooms, offices, workshops, etc., and for the construction of verandas, hothouses, kiosks, bathrooms, hospitals, ice factories, butcher shops, railroad stations, breweries, dairies, stables, factories, and in other localities where cleanliness, much light, and equable temperature are particularly desired. They are utilized in workshops where chemicals producing noxious vapors are manufactured or handled, and for insulating partition walls. The bricks are also manufactured with a wire coating for strictly fireproof walls.

These bricks are manufactured in Dresden, and the "Falconnier" glass building stones are manufactured by the Glasshüttenwerke Adlerhütten Actiengesellschaft, at Penzig, Silesia. No glass bricks are manufactured in this consular district. Their use is still very limited and of little importance.—Hugh Pitcairn, Consul-General, Hamburg, Germany.

(To be continued.)

SILICA COKE-OVEN BRICK.

WHY is the silica brick better than the clay brick? A slight understanding of the manner of manufacture of the latter is necessary. The clay brick used exclusively prior to the advent of the silica brick, and the one used in the majority of coke ovens to-day, is a brick containing about 75 per cent of rock high in silica, and 25 per cent fireclay. This brick is sometimes called a quartzite brick, and a considerable number of them are used in the construction of by-product coke ovens. In this latter oven a brick must be used that does not expand or contract, so that the air-tight chamber used in coking the coal will remain intact. The contradictory action of fireclay and silica under heat, the one expanding and the other contracting, makes it a brick that changes little, if any, in size. Of course the relative amounts of the two materials used would have a very important bearing.

The use of clay in the silica brick we believe is entirely for bonding purposes. We also believe that much of the cause for failure of the clay bond silica brick is due to the inferior quality of clay used in the bonding. The clay is generally some clay that accompanies a coal vein and usually runs very high in impurities. In comparing an analysis of some of these clays with that used by one of the more reliable firms, we find a difference of from 6 to 10 per cent, and even more in the amount of impurities in the clay used.

It is undoubtedly a fact that there are coke ovens in operation to-day with crowns of clay bond silica brick, that in point of service nothing better could be desired. A brick with inferior clay in it soon manifests its inferiority in the clay boiling out in a black pasty mass, and the destruction of the brick rapidly follows. A more careful selection of the clay used in the bond would undoubtedly produce more satisfactory results in the use of this brick, though we still believe the lime bond silica brick is much superior, and in time will replace all clay bond brick for crown purposes.

The modern beehive coke oven now consists of a crown of silica brick with liners or side walls of clay bond brick and the bottom of a clay tile. The question has been brought up, why not use lime bond silica brick for the liners also? But that they will answer the purpose so far as heat resistance goes, can hardly be questioned, and that if durability would depend on this only, they would be superior to the clay bond, but there is a question as to their being as physically strong as the clay bond brick. The liners have to resist the abrading action caused by the withdrawal of the coke, by the tools used in withdrawing the coke, by the falling charge of coal, and the tools used in leveling the charge. The brick will be wet from the quenching of the coke and in the poorest condition to resist abrasion.

A clay brick, no matter how good, vitrifies to some extent and presents a very hard surface far better able to resist abrasion than the grainy lime bond silica brick.

This reasoning may be knocked into a cocked hat

by the trial of silica brick in this position, for their use in this portion of the oven is not as radical a departure as was their substitution for the clay bond brick in the crowns. The only objection heard to the silica brick was that they did not retain as much heat as the clay bond brick, and consequently the charge of coal was a little slower in heating up.—Mines and Minerals.

THE HAMMURABI CODE AND THE CODE OF THE COVENANT.[1]

I. THE DISCOVERY OF THE HAMMURABI STELE.

IN the early winter of 1901-02 there was unearthed at Susa, the capital of ancient Susiana, or Elam, the most important monument of early civilization yet discovered—a law-code antedating the oldest hitherto known by upward of a thousand years.

The French government began the work of uncovering the old Elamite capital some twenty years ago. The director-general of 1884-86, M. Dieulafoy, who almost entirely uncovered one royal palace and sent many interesting monuments to the Louvre, was succeeded by M. J. de Morgan, a man well trained by experience in the Egyptian field. Ten years of work under M. de Morgan brought the excavation down to the foundation of the ruined city. There Hammurabi's famous law-code was found graven in the archaic Babylonian cuneiform on a broken block of diorite 7 feet 4 inches in height. The three fragments into which the monolith had been broken were easily rejoined, and thus completed, the stele was sent to the Louvre. In October, 1902, the great discovery was made known to the world in photogravure, transliteration, and translation.[2]

II. THE ORIGIN OF THE CODE.

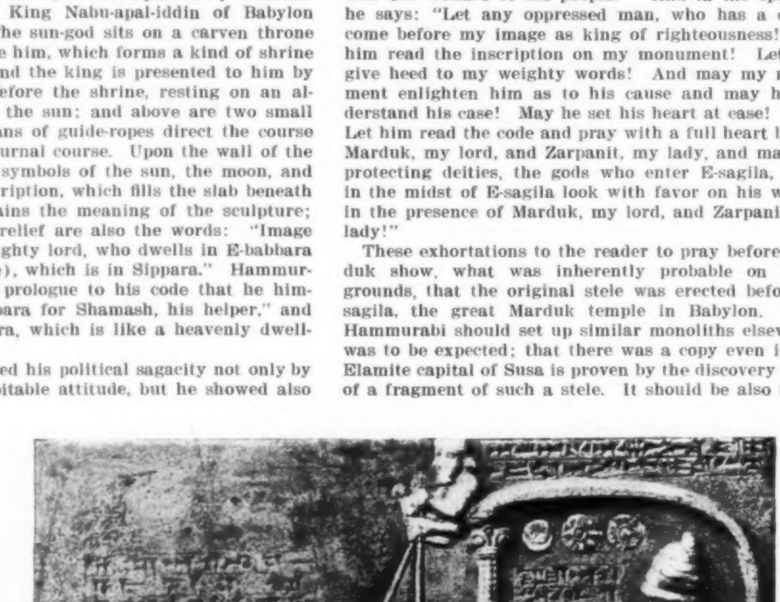
Hammurabi, the compiler of this code, who is identified by most Assyriologists with the Amraphel of Genesis xiv:1, was the sixth king of the first Babylonian consummate statesman as well. He proved himself such, on the one hand, by his conciliatory attitude toward the varying religious affiliations of his new subjects. Throughout the land he repaired and beautified the shrines of the local gods, and thus won the allegiance of their worshipers. Each of the old capitals, Ur, Erech, Nippur, and Lagash to the south and Agane and Sippara to the north, was the seat of some one protecting deity, whose favor he was desirous of gaining. At Sippara the local divinity was the sun-god, Shamash, and it is Shamash's august figure that he had cut in relief on our stele, which once stood there.

The form under which Shamash was once worshiped at Sippara is familiar, for Mr. Hormuzd Rassam[5] in his excavations at Sippara (Abu-habba) found beneath the ruined temple of Shamash a stone tablet with a beautiful bas-relief portraying the worship of the sun-god. This slab, 11½ inches high by 7 inches broad and 2 inches thick, is accompanied by a memorial inscription of King Nabu-apal-iddin of Babylon (879-853 B. C.). The sun-god sits on a carven throne with a canopy above him, which forms a kind of shrine or holy of holies, and the king is presented to him by two attendants. Before the shrine, resting on an altar, is a symbol of the sun; and above are two small figures who by means of guide-ropes direct the course of the sun in his diurnal course. Upon the wall of the shrine are smaller symbols of the sun, the moon, and Venus, and the inscription, which fills the slab beneath the bas-relief, explains the meaning of the sculpture; on the field of bas-relief are also the words: "Image of Shamash, the mighty lord, who dwells in E-babbara (the brilliant house), which is in Sippara." Hammurabi tells us in the prologue to his code that he himself "rebuilt E-babbara for Shamash, his helper," and "decorated E-babbara, which is like a heavenly dwelling."

Hammurabi showed his political sagacity not only by his religiously hospitable attitude, but he showed also which the country was divided before Hammurabi's day, contributed something to the new code. That this material, necessarily so diverse in its origin, should have been so successfully assimilated and recast into a code which was not only harmonious in content, but also logical in form, was an indication of no mean ability in the codifier. Moreover, the code was written in Semitic Babylonian—not in Sumerian, the language of the scholar, but in the vernacular; as Hammurabi says, "I established law and justice in the language of the land." It was all done by the appointment of the great gods. In the prologue Hammurabi defines his mission: "Anu and Bel called me, Hammurabi, the exalted prince, the worshiper of the gods, to cause justice to prevail in the land, to destroy the wicked and the evil, to prevent the strong from oppressing the weak, to go forth like Shamash over the Black Head Race, to enlighten the land and to further the welfare of the people."[7] And in the epilogue he says: "Let any oppressed man, who has a cause, come before my image as king of righteousness! Let him read the inscription on my monument! Let him give heed to my weighty words! And may my monument enlighten him as to his cause and may he understand his case! May he set his heart at ease! . . . Let him read the code and pray with a full heart before Marduk, my lord, and Zarpanit, my lady, and may the protecting deities, the gods who enter E-sagila, daily in the midst of E-sagila look with favor on his wishes in the presence of Marduk, my lord, and Zarpanit, my lady!"

These exhortations to the reader to pray before Marduk show, what was inherently probable on other grounds, that the original stele was erected before E-sagila, the great Marduk temple in Babylon. That Hammurabi should set up similar monoliths elsewhere was to be expected; that there was a copy even in the Elamite capital of Susa is proven by the discovery there of a fragment of such a stele. It should be also noted

PORTRAIT OF HAMMURABI.



BAS-RELIEF ON A TABLET FROM THE TEMPLE OF THE SUN-GOD AT SIPPARA.

dynasty.[3] He was a Semite, of a race which had probably entered Babylonia from Arabia, and had gained a foothold among the non-Semitic Sumerian inhabitants. That Hammurabi and his dynasty did not belong to the native Sumerian stock is indeed evidenced by a Babylonian syllabary in which his name is treated as a foreign one, and is explained by *kimtu rapashtu*, i. e., the great family. Furthermore, Hammurabi describes himself in the prologue to his code as "of the seed royal which Sin begat." This would seem to indicate an Arabian origin, for it is in Arabia that the moon-god Sin[4] was called "the creator-god," and his cult was pre-eminent.

It would seem that the earliest days of the Semitic history of Babylonia were marked by a struggle with the ancient inhabitants, the Sumerians and the Semites alternately holding the mastery. Yet, although the basis of the civilization was Sumerian, the Semites, being strengthened by frequent additions from Arabia, gradually, as time rolled on, obtained the upper hand.

But Sumerians and Babylonians were not the only races brought into conflict there. When in 2250 B. C. Hammurabi came to the throne, it appears that Babylonia had for centuries been oppressed by Elamite invaders. Hammurabi's great military achievement was their expulsion from Babylonian soil; this he accomplished in the thirty-third year of his reign. His remaining years he devoted to the task of consolidating his empire. In his day for the first time in history was the whole of Babylonia united under one scepter, and the sway of her king extended as well to the suzerainty of Elam and Assyria and even to Syria and Palestine as far as the Mediterranean Sea.

Hammurabi was a great conqueror, but he was a that he was a true statesman by establishing a uniform administration of justice throughout his realm. Before his unification of the independent cities of Babylonia into one kingdom there was, of course, no uniform code of laws in force throughout the land. The various small states, into which the country was broken up before his day, had doubtless their own code of customary law. That King Hammurabi drew upon these earlier codes in compiling the laws for his composite people has been proven by the discovery of a number of contract-tablets, antedating the reign of Hammurabi, which contain internal evidence of the existence of a body of laws under which the contracts were drawn up. A comparison of these documents with the laws of Hammurabi shows that the Babylonian law-giver made use of a legal phraseology which had become traditional in his day. All this goes to prove that Hammurabi at least utilized older laws and presumably incorporated some of them bodily in his collection. This conclusion, drawn from the legal phraseology, is based on Babylonian material. An examination of the family laws of the pre-Semitic Sumerians, whom the Semites finally absorbed, leads to the same conclusion; for Hammurabi's code contains a number of formulæ drawn from these Sumerian laws.[6] Remnants of old Sumerian family law, of ancient Arab shepherd law, and of early Babylonian law, as each obtained in the various small states into here that in 1898 broken portions of the code were unearthed in Assurbanipal's famous library at Nineveh (c. 650), which at the time, those keen scholars Dr. Bruno Meissner and Dr. Friedrich Delitzsch declared once formed part of an old Babylonian law-code dating from about 2300 B. C. These fragments, which are in the British Museum,[8] contain 17 enactments besides some 80 lines of the prologue. The Berlin Museum also has two small fragments of the code dating from about 550 B. C.

For many centuries these memorials of his greatness stood in the various cities of the Babylonian kingdom, and then, under a feebler dynasty, the kings from the mountains of Elam again pushed their way in and reconquered the land. Among the booty the spoiler carried off from the city of Sippara to grace his triumph was our copy of the Hammurabi stele. His purpose was no doubt to emphasize the fact that Hammurabi's Babylonian code was now abrogated and that the laws of Elam were to be supreme; but Babylonian civilization and the legislation on which the civilization rested could not so easily be overthrown. Hammurabi's code, being an outgrowth of the conditions of the people, survived not only in Babylonia and Assyria as the basis of all subsequent legislation down to the fall of both empires, but also, carried along with Babylonian trade and literature to all parts of the empire, even, be it noted, to Palestine, survived, so far as modifying conditions allowed, in the life and culture of other peoples.

Hammurabi's stele is an interesting object. It resembles in some respects the one found at Sippara, already described; like that and many other Babylonian monuments, it contains both a bas-relief and text. The bas-relief, which is 26 inches high and 24 inches broad, pictures Shamash seated upon a throne, with sun-rays springing from his shoulders. He wears

[1] From Records of the Past.

[2] V. Scheil, Délégation en Perse. Mémoires publiés sous la direction de M. J. de Morgan, délégué général. Tome IV. Textes Elamites-Sémitiques. Deuxième Série. Paris, 1902.

[3] L. W. King: The Letters and Inscriptions of Hammurabi. Three volumes. London, 1900.

[4] Ditlef Nielsen, Die Altarabische Mondreligion. Strasburg, 1904.

[5] Rassam: Asshur and the Land of Nimrod, p. 402.

[6] A fragment of a tablet in the British Museum numbered K. 251 contains, among others, the following Sumerian laws with Babylonian translation. See Paul Haupt Sumerische Familien Gesetze. Leipzig, 1879; Trans. Soc. Bibl. Archaeology, vol. viii., p. 230. With the first two compare Hammurabi Code, 192, 146; with the 3, Hammurabi Code, 142, 143, with the 4, Hammurabi Code, 137-140.

1. If a son say to his father, "My father thou art not," they shall brand him and sell him as a slave for silver.

2. If a son say to his mother, "My mother thou art not," his forehead they shall brand, from the city they shall banish him, from the house they shall drive him.

3. If a wife hate her husband and say, "My husband thou art not," into the river they shall throw her.

4. If a husband say to his wife, "My wife thou art not," half a mana of silver he shall weigh out to her.

[7] Most of the translations given in this study are based on Robert F. Harper: The Code of Hammurabi. Chicago, 1904.

[8] British Museum tablets: No. R. M. 277 and No. D. T. 81.

the swathed headgear so common in Babylonian representations, and is clothed in a long flounced robe. His extended right hand clasps a ring and what may be either a scepter, the symbol of authority, or a stylus, the symbol of wisdom; compare also the very ancient Babylonian cylinder which represents the sun-god in his nightly journey across the waters of the underworld. In front of Shamash and facing him stands King Hammurabi in an attitude of adoration. As Hammurabi speaks of himself in the epilogue to the code as "the king of right to whom Shamash has communicated the laws," the bas-relief would seem to be a portrayal of Hammurabi in the act of receiving from Shamash, "the judge of gods and men," the laws with which the rest of the stele is taken up. The king has upon his head a cap with fillet, and he is clothed in a long tunic, hemmed in at the waist and reaching in long folds to his feet. His right hand is raised in a gesture of reverent worship, and his left is crossed before him and rests against his waist. It will be seen that this representation of Hammurabi differs very slightly from the portrait sculpture of him in the possession of the British Museum. Such is the bas-relief; below it there is the inscription, which covers also the back of the monument. There are some 3,600 lines of text, which are arranged in 44 columns, and in addition to a prologue and epilogue record 282 edicts. The Elamite conqueror who carried off the stele to Susa caused 5 columns, containing some 35 ordinances, to be chiseled out and polished smooth, evidently with the intention of inscribing upon the stele a record of his own achievements—a purpose, however, which he never fulfilled. The contents of these erased columns can be in part surmised from the fragments of the code found in Assurbanipal's library.

III. AN ANALYSIS OF THE CODE.

Hammurabi or his jurists followed a well-considered order in their arrangement of the code. His fundamental principle[9] was "the logical relation of the individual laws to one another. Several related laws form a group, several groups a larger group, several of these a still larger group."

The first five enactments are in the nature of an introduction; as is very proper for the opening of a law-code they go to the very source of all justice and deal with false accusation and impartial trials. The opening enactment is most sweeping: "If a man bring an accusation against a man and charge him with a (capital) crime, but cannot prove it, he, the accuser, shall be put to death." The second specifies a not impossible case of false accusation in a land addicted as Babylonia was to magic and incantation—the accusation of using sorcery: "If a man charge a man with sorcery, and cannot prove it, he who is charged with sorcery shall go to the river; into the river he shall throw himself, and if the river overcome him, his accuser shall take to himself his house (estate). If the river show that man to be innocent, and he come forth unharmed, he who charged him with sorcery shall be put to death. He who threw himself into the river shall take to himself the house of his accuser." The next three enactments have to do with further offenses against the purity of the court: bearing false witness and the venality of a judge. In the latter case the corrupt judge was required to pay twelve times the amount of his false judgment and was expelled from the bench.

Barring this introductory section (1-5), the enactments of the code are arranged under two topics, according as they have to do with Property (6-126) or the Person (127-282). Each of these topics is subdivided into three groups. Property is considered under the divisions of Personal Property (6-25), Real Estate (26-) and Trade and Business Relations (-126), the Person under the divisions of the Family (127-195), Injuries (196-214), and Laborers and Labor (215-282).

In the consideration of property (6-126), in particular personal property (6-25), theft is first taken up and is analyzed under degrees of guilt. Under theft of things (6-13), a theft from the temple or the palace (6-8) was treated much more severely than a theft from a private house (9-13). If the goods be temple or palace furniture or treasure, the punishment is death; if it be a sheep or the like, or a boat that is stolen, the thief must restore it 30 fold. It is noteworthy that the thief and the receiver of stolen goods are held as equally guilty. Kidnapping a minor (14), inducing a slave to run away, harboring or appropriating a slave, are all (15-20) as theft punishable by death, as are also the more aggravated forms of theft (21-25), house-breaking and brigandage. The section ends with a particular case of theft: If one commit theft in a burning house, "that man shall be thrown into that fire."

In the group of laws on real estate there is a large collection relating to officials who were as feudatories endowed with estates, for whose good conduct they were responsible to the king (26-41). The consideration of the fields of these vassals paves the way for a new section.

This section on private property (42) is made up of enactments relative to the cultivation of fields in general (42-56), the responsibilities of shepherds (57-58), and various regulations concerning gardeners (59-65). Two of these regulations are remarkable for wisdom and justice: The rule that in case flood or drought has destroyed a debtor's crop, the payment of interest may not be demanded of him for that year; and the statement, which incidentally throws some light on the irrigation system, that any one who neglected to keep his dyke, or the part of it for the good condition of which he was responsible, in proper repair, was liable for the damage caused by a breach and had to make good the ruined grain.

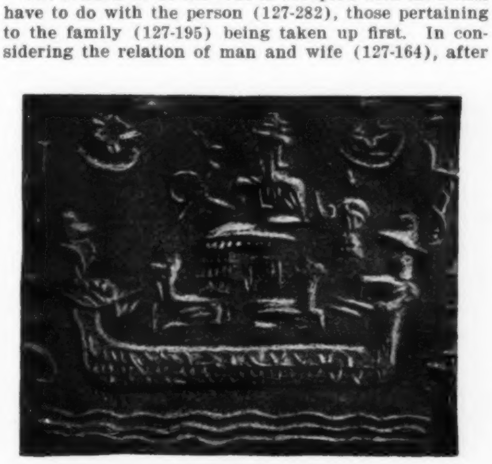
Then follows a gap in the cuneiform text, which occupies the remainder of the front of the stele. It is

THE HAMMURABI STELE.

estimated that 35 edicts have been lost. As those which begin on the reverse of the monument deal with merchants and their agents and are inadequately few (100-107), it has been plausibly conjectured that other enactments relating to agriculture and to the rental of houses which have been recovered elsewhere, once formed part of the sections here missing.

In the section on trade and business (-126), after a consideration of merchants in general, follow four enactments (108-111) relating to winesellers, who seem to have been women, and the orderly conduct of their business. The last edict, which refers to selling drink on credit, develops naturally into sections relating to debt (112-119), and storage and deposit (120-126); and these conclude the laws relating to property.

The remainder of the code is occupied with laws that have to do with the person (127-282), those pertaining to the family (127-195) being taken up first. In considering the relation of man and wife (127-164), after



BABYLONIAN CYLINDER-SEAL.

an enactment on the slander of a wife and one on the marriage contract, the code devotes a considerable section (129-143) to laws governing the interruption of the marriage relation. In these laws, and those that follow on the rights of wives (144-152), the interest of the family as an institution is closely guarded, but a noteworthy consideration for the rights of the woman is everywhere apparent. A man who slandered a woman was to be branded on the forehead. A man who forced a betrothed woman was to be put to death and the woman was to go free. If a soldier be captured and there be no maintenance in his house for his wife, and she "enter into another house, that woman has no blame." In case, however, she have children, if later her first husband return, she shall return to him, but the children shall remain with their father. If a man desert his city and wife, and his wife marry another, her first husband, if he return, cannot lay claim to her. If a man wish to divorce his wife, her rights are clearly defined; he must give her money to the amount of her marriage settlement and he must make good to her the dowry which she brought from her father's house. Furthermore, a case similar to that of Abraham's wife Sarah and her bondmaid Hagar (Gen. xvi) is carefully provided for: "If a man take a wife and she give a maid-servant to her husband, and that maid-servant bear children and afterward would take rank with her mistress, because she has borne children, her mistress may not sell her for money, but she may reduce her to bondage and count her among the maid-servants." The legislation protecting an invalid wife is most humane: "If a man take a wife and she become afflicted with disease, and if he set his face to take another, he may. His wife, who is afflicted with disease, he shall not put away. She shall remain in his house which he has built and he shall maintain her as long as she lives." After an enactment that "a woman who brings about the death of her husband for the sake of another man shall be impaled," there follows a small series bearing on the various forms of incest (154-158), especially between a betrothed woman and her prospective father-in-law, and this is followed by regulations (159-161) respecting breach of promise and the consequent disposition of the bride-price or groom's present to his father-in-law (*tirkhatu*),[10] the dowry given by the father to the bride (*sheriqtu*),[11] which often included the bride-price, and the settlement (*nudunnu*)[12] the groom sometimes made upon his bride. The three sections which follow (162-164) decide the disposition of these in case of the wife's death. The laws of inheritance in general are naturally considered next (165-184); they range over the rights of children and widowed mothers, the rights of male and female slaves and their children, the right of a widow to re-marry, the rights of a priestess or a devotee, the rights of a concubine. A series on the adoption of a child (185-191) follows, and with four laws setting forth the punishment for certain possible crimes incident to the family (192-195) the laws relating to the family come to an end. Renunciation on the part of an adopted child of his foster father or mother was to be punished by mutilation, by the cutting out of his tongue or the plucking out of his eye, and the nurse who substituted another child for one who has died in her house while under her care was to have her breast cut off. The son who struck his own father was to have his fingers cut off.

The transition from these to a division dealing with injuries (196-214) is natural. The *lex talionis* is here somewhat in evidence. "If a man destroy the eye of another man, they shall destroy his eye." "If one break a man's bone, they shall break his bone." "If a man knock out a tooth of a man of his own rank, they shall knock out his tooth." "If a man strike a man's daughter and bring about a miscarriage, and that woman die, they shall put his daughter to death." The laws quoted are the only ones demanding such cruel retaliation. In many cases composition is allowed and injuries are appraised on a regular sliding scale, the penalty in the case of injury to a freeman being greater than for a like injury to a freedman or a slave.

The next group of laws, those on laborers and labor (215-282), more particularly free labor (215-240), furnishes some of the most interesting enactments of the code, those relating to the operations and errors of surgeons, veterinaries, and branders (215-227). Surgeons received fees, graduated according to the social standing of their patient; this was in case of a cure. In case death claimed the patient, if he were a slave, the unfortunate surgeon had to restore to the owner a slave of equal value; if he were a freeman or a freedman, the surgeon had his unskilled fingers cut off. The code in like manner regulated the fees of veterinary surgeons and their fines for failure to cure.

The code interests itself next with house-builders and their responsibilities (228-233). The *lex talionis* appears here again. "If a builder build a house for a man and do not make its construction firm, and the house which he has built collapse and cause the death of the owner of the house, that builder shall be put to death." "If it cause the death of a son of the owner of the house, they shall put to death a son of that builder." "If it cause the death of a slave of the owner of the house, he shall give to the owner of the house a slave of equal value." House-building leads naturally to the consideration of boat-building, and this to boatmen and their responsibilities (234-240). So much for skilled labor.

The enactments that follow have to do with unskilled labor (241-277). First we have the laws governing

[9] The writer acknowledges his indebtedness in this analysis to his friend and sometime teacher in Babylonian-Assyrian, Prof. David G. Lyon, Ph.D., of Harvard University, from whose article on "The Structure of the Hammurabi Code" he here quotes; cf. Journal of American Oriental Society, Vol. xxv., 2, p. 248 ff.

[10] Compare the Hebrew *mohar* (Ex. xxii:15, Gen. xxxiv:12, I. Sam. xviii, 25-27). In old Arabic custom the *mohar* was sometimes given, not to the father-in-law, but to the bride.

[11] The only case of dowry (*berakah*, "blessing") in the Old Testament occurs in Judges i:15 and the parallel narrative, Jos. xv:19; unless the passage Gen. xxxi:15 shows that among the early Hebrews, as among the Arabs, the *mohar* sometimes became the bride's dowry.

[12] In Gen. xxxiv:12 we find a marriage settlement (*mattan*) noted.

agricultural life—oxen, their hire and care, the wages of field-laborers, herdsmen, shepherds, and artisans, and their responsibility for loss. And the code concludes with five enactments (278-282) on the purchase of slaves, and the heavy penalty to be inflicted on the slave guilty of an attempt to repudiate his master—"his master shall prove him to be his slave and shall cut off his ear."

IV. THE CODE OF THE COVENANT.

Before the discovery of the Hammurabi stele, the legislative portions of the Old Testament had long held the distinction of being the oldest extant collection of laws in the world; for the ancient Egyptian code to which Diodorus Siculus (57 B. C.) alludes[13] has unfortunately never been recovered, and as for the noteworthy collections of antiquity which have been preserved to us, even the Hindoo code called the Laws of Menu (c. 950 B. C.), and the Laws of the Twelve Tables of Rome (formulated c. 450 B. C.) are confessedly younger than the oldest law-collections of the Pentateuch. These two oldest codes, the Hammurabic and the Pentateuchal, are therefore brought into comparison, and the question is raised as to the possible relation of the one to the other. A comparison cannot, however, be profitably instituted with the Pentateuch as a whole, for the legislation of the Pentateuch has been shown by literary criticism to consist of different strata. Of these, that portion which Exodus xxiv:7 calls the Book of the Covenant is now generally recognized as the oldest. The successive strata—the Decalogue (Ex. xx:1-17), the Deuteronomic Code (Deut. xii-xxvi), and the Holiness Code (Lev. xii-xxvi)—were of later origin, publication, and addition to what had become generally known as the Law of Moses. Each of these codes might be compared with that of Hammurabi and parallels found; but as it is not in the development of the Hebrew law but in its origin that we are interested, we shall confine our examination to the Book of the Covenant. Hexateuchal criticism is agreed that the Book of the Covenant (Ex. xx:22-xxiii:33) is the oldest law collection in the Old Testament. We need not here discuss its date, for we have a sufficient *terminus a quo* in the fact that the code could have been worked out only by an agricultural people, having settled possessions in house and field.

The older criticism treated the Book of the Covenant as though it were a homogeneous composition; but it has been since perceived that it is in reality compiled from two earlier collections.[14] The one collection was made up of cultus laws which were called "Words" (*debharim*). This collection (Ex. xx:22-26, xxii:29-31, xxiii:10-19, 20-33) was concerned exclusively with instructions for the proper worship of Yahveh. Its enactments were not founded on custom and usage, but were regarded as derived immediately from Yahveh, and as owing their origin to a personal command from Him. These "Words," we are told, were recorded by Moses in a book, and it was on the basis of these "Words" that Yahveh entered into a covenant with Israel (cf. Ex. xxiv:4-8).

The other collection from which the Book of the Covenant was compiled was a book of "Judgments" (*mishpatim*).[15] These enactments or decisions of judges have to do with the protection of life and property, and they consequently form a civil and criminal code. It is this secular code (Ex. xxi:1-xxii:28, xxiii:1-9) that we must now compare with the civil and criminal code of Hammurabi.

[13] Diod. I.

[14] Consult George F. Moore's Article, "Exodus (Book)," in Encyclopaedia Biblica, vol. ii.

[15] Hammurabi calls his code "judgments, or enactments, of justice." Col. XL, l. 1.

V. THE COVENANT CODE AND THE CODE OF HAMMURABI.

THE TREATMENT OF SLAVES.

Ex. xxi:2. If thou buy a Hebrew slave, he shall serve 6 years; and in the 7 year he shall go free without money.

xxi:7. If a man sell his daughter to be a maid-servant, she shall not go out as the man slaves do.

The Hebrew Code provides further for the maid-servant:

xxi:8-11. If she please not her master who designated her for himself (i. e., as a concubine), then shall he suffer her to be redeemed; he shall have no power to sell her to a foreign people, because he hath dealt unfaithfully with her. And if he designated her for his son, he shall deal with her according to the right of daughters. If he take another woman for himself, he shall not diminish her flesh-meat, her clothing, and her cohabitation. And if he do not these 3 things to her, then shall she go out for nothing without money.

117. If a man be in debt and sell his wife, son, or daughter, or bind them over to service, for 3 years they shall work in the house of their purchaser or master; in the 4 year they shall be given their freedom.

The Babylonian Code shows the same feeling in regard to the estrangement of slaves from their native land:

280. If a man purchase a male or female slave in a foreign country, and if, when he comes back to his own land, the (former) owner of the male or female slave recognize his male or female slave—if the male or female slave be a native of the land, he shall grant them their freedom without money.

In another place the Babylonian Code provides:

171. If the father during his lifetime have not said to the children which the maid-servant bore him: "My children"; after the father dies, the children of maid-servant shall not share in the goods of the father's house with the children of the wife. The maid-servant and her children shall be given their freedom. The children of the wife may not lay claim to the children of the maid-servant for service.

In the matter of slaves, therefore, both codes provide that the period of service shall be limited. The Hebrew frees the bond servant in the 7 year; the Babylonian in the 4 year. In the case of the bond women, the Hebrew code provides that they be not sold into foreign servitude; the Babylonian provides that all slaves discovered in foreign lands shall be set free. The Hebrew code further provides that the bond woman to whom her master does not fulfill the 3 conditions of concubinage shall go free; the Babylonian provides that even though her master should die without having recognized her children as his own, they may not be held as slaves—she and her children shall go free.

ACCIDENTAL HOMICIDE.

Ex. xxi:12-13. He that strikes a man so that he die, shall surely be put to death. But if a man lie not in wait, but God caused it to happen to his hand, I will appoint thee a place to which he shall flee (viz., the altar).[16]

206-8. If a man strike another in a quarrel and wound him, if he die as the result of the stroke, he shall swear: "I struck him without intent," and if he be a man (i. e., freeman), he shall pay one-half mana of silver; if a freedman,[17] one-third mana of silver.

ATTACK UPON PARENTS.

Ex. xxi:15. He that strikes his father and his mother shall surely be put to death.

Ex. xxi:17. He that curses his father or his mother shall surely be put to death.

195. If a son strike his father, they shall cut off his fingers.

192. If the son of a *nersega*, or the son of a devotee, say to his foster-father or his foster-mother, "My father thou art not," or "My mother thou art not," they shall cut out his tongue.[18]

MAN-STEALING.

Ex. xxi:16. He that steals a man, one of the children of Israel, whether he shall sell him or whether the stolen man be found in his hand, shall surely be put to death.

14. If a man steal a man's son, he shall be put to death.

BODILY INJURIES.

Ex. xxi:18-19. If men contend, and one strike the other with a stone, or with his feet, and he die not, but keep his bed; if he rise and walk abroad upon his staff, then he that struck him shall be quit, only he shall pay for the loss of his time and shall cause him to be thoroughly healed.

206. If a man strike another in a quarrel, and wound him, he shall swear: "I struck him without intent," and he shall be responsible for the physician.

196. If a man destroy the eye of another man, they shall destroy his eye.

197. If one break a man's bone, they shall break his bone.

200. If a man knock out a tooth of a man of his own rank, they shall knock out his tooth.

Compare also the law governing the responsibility of a herdsman:

Ex. xxi:26-27. If a man smite the eye of his servant, or the eye of his maid, and destroy it, he shall let him go free for his eye's sake. And if he smite out his man-servant's tooth, or his maid-servant's tooth, he shall let him go free for his tooth's sake.

263. If he lose an ox or sheep which is given to him, he shall restore to their owner ox for ox, sheep for sheep.

199. If one destroy the eye of a man's slave, or break a bone of a man's slave, he shall pay ½ his price.

CRIMINAL NEGLIGENCE.

Ex. xxi:28. If an ox gore a man or a woman that they die, the ox shall surely be stoned, and his flesh shall not be eaten,[19] but the owner of the ox shall be quit.

Ex. xxi:29-31. But if the ox were wont to gore in time past and it has been made known to his owner and he has not kept him in, and he shall kill a man or a woman, the ox shall be stoned and his owner also shall be put to death. If there be laid on him a ransom, then he shall give for the redemption of his life whatsoever is laid upon him. Or if it has gored a son or a daughter, according to this judgment shall it be laid upon him.

Ex. xxi:32. If the ox gore a male or female slave, he shall pay their master 30 shekels (i. e., ½ mana) of silver, and the ox shall be stoned.

250. If a bull, when passing through the street, gore a man and bring about his death, this case has no penalty.

251. If a man's bull have been wont to gore, and they have made known to him his habit of goring, and he have not protected his horns or have not tied him up, and that bull gore the son of a man and bring about his death, he shall pay ½ mana of silver.

252. If it be the servant of a man, he shall pay 1/[illegible] mana of silver.

[16] Cf. Otto Procksch: Ueber die Blutrache bei den vorislamischen Arabern, p. 44. Leipzig, 1899.

[17] *Mash-en-kak.* The status of the men so designated is in dispute; they seem to have ranked between the men of property and position and the men of slaves; possibly a freedman; cf. Hebr. *misken*, "a poor man."

[18] Compare the Sumerian laws quoted above.

[19] Compare the similar custom among pre-Islamic Arabs; also Recht der Bogos, sec. 204.

HOUSE-BREAKING.

Hebrew and Babylonian houses were as a rule very rudely and insecurely built, and the walls, consisting of clay, were easily broken through by thieves. Both of our codes take cognizance of this. Slaying a house-breaker at night in self-defense is allowed by the Covenant Code;[20] the Hammurabi Code gives the householder an even greater right:

Ex. xxii:2-3. If a thief be found breaking in and be struck that he dies, he (i. e., the slayer) shall not incur the guilt of bloodshed. If the sun be risen upon him, he shall incur the guilt of bloodshed. He (i. e., the thief) shall surely make restitution; if he have nothing, then he shall be sold for his theft.[21]

21. If a man make a breach in a house, they shall put him to death in front of that breach, and they shall thrust him therein.

TRESPASS AND LOSS.

Ex. xxii:5. If a man shall cause (his own) field or vineyard to be eaten, and shall let his beast loose, so that it feed in another man's field, of the best of his own field and of the best of his own vineyard, shall he make restitution.[22]

57. If a shepherd have come not to an agreement with the owner of a field to pasture his sheep on the grass, and if he pasture his sheep on the field without the consent of the owner, the owner of the field shall harvest his field, and the shepherd who has pastured his sheep on the field without the consent of the owner of the field shall give over and above 20 *gur* of grain per 10 *gan* to the owner of the field.[23]

Ex. xxii:7-8. If a man deliver unto his neighbor money or goods to keep, and they be stolen from the man's house; if the thief be found, he shall restore two-fold. If the thief be not found, the owner of the house shall come near to God (to see) whether he have not put his hand on his neighbor's goods.

Ex. xxii:9. For every matter of trespass, whether it be for ox, for ass, for sheep, for raiment, or for any manner of lost thing, whereof one says, "This is it," the cause of both parties shall come before God; he whom God shall condemn shall restore two-fold to his neighbor.

125. If a man give anything of his own on deposit, and at the place of deposit, either by burglary or pillage, he suffer loss in common with the owner of the house, the owner of the house who has been negligent and has lost what was given to him on deposit shall make good (the loss) and restore (it) to the owner of the goods; the owner of the house shall institute a search for what has been lost and take it from the thief.

124. If a man give to another silver, gold, or anything else on deposit in the presence of witnesses, and the latter dispute with him (or deny it), they shall call that man to account, and he shall double whatever he has disputed and repay it.

126. If a man have not lost anything, but say that he has lost something, or if he file a claim for loss where nothing has been lost, he shall declare his (alleged) loss in the presence of God, and he shall double and pay for the (alleged) loss the amount for which he had made claim.

Ex. xxii:10-11. If a man shall give his neighbor an ass, or an ox, or a sheep, or any beast, to keep, and it die, or be hurt or driven away, no man seeing it:

9. If a man, who has lost anything, find that which he has lost in the possession of (another) man; and the man in whose possession the lost

[20] The XII. Tables (viii:12, 13) similarly allow that a thief caught at night in the act may be killed; but not after sunrise, unless he be armed and offer resistance.

[21] The same provision for making restitution is found in the Babylonian law concerning the man who neglects to keep his dyke in repair, and so brings ruin upon his neighbor's field (53, 54): "The man in whose dyke the break has been made shall restore the grain which he has damaged. If he be not able to restore the grain, they shall sell him and his goods, and the farmers whose grain the water has carried away shall share (the results of the sale)."

[22] The text of the verse has been restored from the Samaritan and Septuagint versions.

[23] The XII. Tables (vii:6, 7) prescribe that in case a quadruped damage the field of a neighbor, unless the owner make compensation, the quadruped shall be given to the aggrieved neighbor. If the owner intentionally pasture his flock in his neighbor's field, he shall be liable to action at law.

the oath of Yahveh shall be between them both whether he has not put his hand on his neighbor's goods; and the owner thereof shall accept (the oath), and he shall not make restitution.	property is found say: "It was sold to me, I purchased it in the presence of witnesses"; if the purchaser produce the seller who has sold it to him and the witnesses in whose presence he purchased it, and the owner of the lost property produce witnesses to identify his lost property, the judges shall consider their evidence. The witnesses in whose presence the purchase was made and the witnesses to identify the lost property shall give their testimony in the presence of God. The seller shall be put to death as a thief; the owner of the lost property shall recover his loss, the purchaser shall recover from the estate of the seller the money which he paid out.
Ex. xxii:12. But if it be stolen from him, he shall make restitution to its owner.	266. If a visitation of God happen to a fold, or a lion kill, the shepherd shall declare himself innocent before God, and the owner of the fold shall suffer the damage.
Ex. xxii:13. If it be torn in pieces, let him bring it as a witness: he shall not make good that which is torn.[24]	267. If a shepherd be careless, and he bring about an accident in the fold, the shepherd shall make good in cattle and sheep the loss through the accident which he brought about in the fold, and give them to their owner.
Ex. xxii:14. If a man borrow (a beast) of his neighbor, and it be hurt or die, the owner thereof not being with it, he shall surely make restitution; if it was hired, it came for its hire.	244. If a man hire an ox or an ass, and a lion kill it in the field, it is the owner's affair. 263. If (a herdsman) lose an ox or a sheep which is given to him, he shall restore to their owner ox for ox, sheep for sheep.

SEDUCTION.

Ex. xxii:16. If a man entice a virgin who is not betrothed, and lie with her, he shall surely pay a bride-price for her to be his wife.	130. If a man force the (betrothed) wife of another who has not known a male and is living in her father's house, and he lie in her bosom, and they take him, that man shall be put to death and the woman shall go free.

PLEDGE.

Both codes exhibit here a humane feeling: the Hebrew, addressing itself to wandering tribesmen, to whom, as to the Bedouin of to-day, their cloaks were their covering by night, legislates against the taking of these in pledge; the Babylonian, addressing itself to a community, a large part of which were agriculturists and thus dependent on their oxen for their means of support, legislates against taking from them this means of earning their living.

Ex. xxii:26. If thou at all take thy neighbor's garment to pledge, thou shalt restore it to him by sundown, for that is his only covering.	241. If a man seize an ox for debt, he shall pay 1/3 mana of silver.

JUDICIAL INTEGRITY.

Ex. xxiii:1-3, 7-8. Thou shalt not take up a false report: put not thine hand with the wicked to be an unrighteous witness. Thou shalt not follow a multitude to do evil; neither shalt thou bear witness in a cause to turn aside after a multitude to wrest judgment. . . . Keep far from a false matter; and the innocent and righteous slay thou not: for I will not justify the wicked. And thou shalt not take a gift: for a gift blindeth those that have sight and perverteth the words of the righteous.	3. If a man, in a case (pending judgment), bear false witness, or do not establish the testimony that he has given, if that case be a case involving life, that man shall be put to death. 4. If a man (in a case) bear witness for grain or money (as a bribe), he shall himself bear the penalty imposed in that case. 5. If a judge pronounce a judgment, render a decision, deliver a verdict duly signed and sealed, and afterward alter his judgment, they shall call that judge to account for the alteration of the judgment which he had pronounced, and he shall pay twelvefold the penalty, which was in said judgment; and in the assembly, they shall expel him from his seat of judgment, and he shall not return, and with the judges in a case he shall not take his seat.[25]

[24] Baentsch suggests that Jacob's words to Laban, referring to the old shepherd law (Gen. xxxi:39, E), display a knowledge of the Book of the Covenant.

VI. CONCLUSION.

Our comparison of the Hebrew Code with the Babylonian has made apparent a general similarity, the enactments of both being put in the same hypothetical form; but this contingent form is by no means peculiar to these codes. Besides, this is superficial. More striking is the remarkable resemblance in substance—the many cases of similar or analogous legislation. These are too numerous to admit the explanation of accidental resemblance, and they consequently raise the question of the relation of the two codes. It being manifestly impossible on chronological grounds that the Babylonian laws could have been borrowed from the Biblical, it would seem that only two possible theories remain—either both codes must have been derived from a common source, or the Covenant Code must have been influenced directly or indirectly by the Code of Hammurabi. It would seem, however, that this is not a case where either of two theories is tenable and the other untenable, but a case where both theories are true in part.

The advocates of the former theory, who hold that the codes had a common origin in ancient customary law, have a strong argument. The Hammurabi dynasty was a foreign one, presumably coming from the original Semitic home in Arabia. Furthermore, from the time of Gudea (c. 3000 B. C.) trade relations had existed between Arabia and Babylonia, and traffic with Arabia would inevitably bring in its train further knowledge of Arabian customs and laws. By Hammurabi's day, and probably much earlier, these early elements and importations would have been digested and absorbed into the general body of Babylonian law, and the whole would have assumed a form distinctly Babylonian.

Those who hold this theory refer back the Covenant Code also to ancient Arabic customary law, and claim for it the same process of development. Exodus xviii: 14-16 says that Moses,[26] the great law-giver of the Hebrews, had for his teacher his father-in-law, the Arabian Kenite Jethro, who instructed him in the method of legal procedure. The value of this tradition, preserved by an early Elohistic prophetic writer, is frankly and gratefully recognized. But whatever Moses may have learned from Jethro, it certainly was not a code of laws applicable to the needs of a settled agricultural community. What the Bedouin sheikh imparted to him was such customary laws as had grown up and were usable in the nomad life of Arabia. How the Hebrews developed this law under new agricultural conditions in Canaan is another question, and brings us to the second theory—that the Covenant Code was directly or indirectly influenced by the Code of Hammurabi.

When the Hebrews effected a settlement in Canaan they found there a people greatly their superior in culture; learning from this people the arts of civilization, they gradually passed from the unsettled life of nomad herdsmen into that of settled agriculturists. Their new home had long been under Babylonian influence. For centuries, certainly since the days of Abraham, which were also the days of Hammurabi, the rule of Babylon had extended to the shores of the Mediterranean Sea; and at the time of the Tel-el-Amarna tablets (c. 1450 B. C.), shortly before the Hebrew settlement in Canaan, not only, as these letters show, was there a lively intercourse with Babylon, but the Babylonian language and cuneiform writing were actually used throughout Palestine in carrying on international communication. In their new home, therefore, the Hebrews found themselves in a land permeated with Babylonian influence and culture; that they were not unaffected by these is apparent in their earliest literature and institutions. The earlier chapters of Genesis rehearse stories first told on the banks of the Euphrates, and tell of institutions which had their beginnings in Babylonia. The Hebrew Sabbath, in both name and institution, was of Babylonian origin, however peculiarly Hebrew may have been its later development in Palestine. There was much beside in the Hebrew ritual and theological conceptions bearing marks of Babylonian source. As the Hebrews appropriated ancient Babylonian legends and institutions and recast them in accordance with their peculiar national genius, so, when the possession of landed property and the conditions of their new life in Canaan developed the need of fixed laws, they must have appropriated and adapted to their own use many of the provisions of the Babylonian law, in force long before their coming. But the foundation of the Babylonian law was the code of Hammurabi, and thus the enactments of the old Babylonian king, formulated in the XXIII Century B. C., passed more than 1,000 years later into the Book of the Covenant, and so became the heritage of the Hebrews and of the world. MAX KELLNER.

Episcopal Theological School, Cambridge, Mass.

[25] The XII. Tables (ix) ordered the execution of any judge convicted of receiving a bribe.

[26] The legend preserved in the Priestly History Book (Gen. xi:31; xii:4), that Abraham, the Hebrew race-father, was a native of Ur of the Chaldees is not cited here. Quite apart from the question of historicity of the statement, one might doubt whether whatever recollection of Babylonian law the Abrahamidæ may have carried into the west would not soon become obliterated through disuse. As for the influence of the Babylonized life of Canaan upon Abraham, Isaac, and Jacob, the same principle of unusableness would still be effective. Customs and laws can only there be introduced into the life of a people where they find an application to similar modes of life, social conditions, and interests. Babylonian law never affected the Bedouin, who pressed even up to the borders of Babylonia, and it was because of the wide difference in viewpoint and modes of life that severed the two peoples. We can think of the Babylonian and proto-Hebrew life as furnishing the same contrast. Of what use could Hammurabi's highly developed law be to a band of rude nomads?

THE MAMPEL FAMILY: A RARE DISEASE AND A REMARKABLE LAW OF HEREDITY.

By DR. BOEHME, in Umschau.

HAEMOPHILY, or "bleeding sickness," has been known for more than a century. It is a rare disease and is confined to certain families in which it may be traced for generations. It is characterized, as the name suggests, by an extraordinary tendency to effusion of blood. A fall, a slight blow, the prick of a pin, may occasion severe, even a fatal hemorrhage. It is not even necessary that the skin should be broken. The "bleeder" is subject to effusions of blood, in the subcutaneous tissue, often without apparent cause, and is very liable to hemorrhages from the nose, gums, tongue, and the mucous membranes of the stomach and bowels, or from other vital organs such as the kidneys and the brain. So slight a surgical operation as the extraction of a tooth is extremely dangerous in the case of a "bleeder."

These hemorrhages are not due to ruptures of large blood vessels but the blood flows from the tissue as from a squeezed sponge. In a normal individual a small wound soon becomes covered with a firmly-adhering clot of coagulated blood which prevents further bleeding. In a "bleeder" a clot is also formed, as a rule, but it does not adhere to the wound and is soon carried away by the pressure of the escaping blood, which therefore continues to flow.

In internal hemorrhages there is a still greater difference between the normal man and the "bleeder." Under these conditions the blood of the latter coagulates very slightly, if at all, while normal blood coagulates within the body as well as without. This fact explains the difference in the adherence of the clot to an external wound in the two cases. In one, coagulation is only superficial, while in the other, the normal man, it penetrates deeply so that the clot becomes firmly rooted in the flesh. But the fact itself, the diminished tendency to coagulation exhibited by the blood of certain persons, remains unexplained. We know that normal coagulation is conditioned by the presence in the blood of certain specific ferments, extremely small quantities of which suffice to effect coagulation. Are these ferments entirely absent from the blood of "bleeders," or does this contain other substances which destroy their activity? The solution of these problems would probably give us an insight into the true nature of the disease and a rational and possibly successful method of treatment.

The tendency to hemorrhage varies greatly. In the same family may be found every gradation, from the severest type down to rather frequent bleeding at the nose or a somewhat more copious flow of blood than is normal after a wound. Usually, too, some of the males and *all* of the females show no symptom of the disease.

In other respects "bleeders" differ in no way from normal persons. Many, even of those who have had frequent and very severe hemorrhages, attain advanced age. In general, they recover from hemorrhages with surprising rapidity.

The most interesting peculiarity of the disease, regarded from a scientific point of view, is the remarkable law of heredity which it illustrates. This law has long been known in a general way, for more than sixty European families of "bleeders" had been recognized and studied twenty years ago, but in no other instance has it manifested itself so clearly and sharply as in the case of the Mampel family whose history for more than a hundred years has been investigated by Prof. Lossel, of Heidelberg, and described by him in a recent article in the Deutsche Zeitschrift fuer Chirurgie.

The first of the family of whom anything is known were one Johann Peter Mampel and his wife, neither of whom was a "bleeder." They had eleven children. ("Bleeding" families, by the way, are noted for fecundity.) Of the six sons two died in infancy and three developed into unmistakable "bleeders," but neither the remaining son nor any of the five daughters ever showed any symptom of the disease. All the children of all the sons were likewise exempt and so were the daughters of the daughters, but in the sons of the daughters the disease reappeared. The same rule holds in the next and all succeeding generations. All the children, both male and female, of the "bleeding" men have been normal, while the women of the family, normal themselves, have given birth to sons of whom nearly all were "bleeders" and to daughters of whom quite all were normal.

The law of heredity, therefore, as deduced from the 212 members of this family is this:

Though the disease is confined to males it is never transmitted by these male "bleeders" to their children, but only by the (normal) women of the family to their sons.

The women, therefore, transmit a peculiarity which they have never had, or, more properly, have never manifested, in their own persons. A necessary consequence of this is that no "bleeder" can be found among the ancestors of a "bleeder," though his uncles, grand-uncles, great-grand-uncles, etc., are likely to have suffered from the disease. The law leads to the conclusion that the wife of Johann Peter Mampel belonged to a family of "bleeders," but, unfortunately, documentary evidence is wanting as her ancestry cannot be traced.

The law has been confirmed, in general, by observations on other families. Occasionally, though very rarely, however, a female "bleeder" is found.

The transmission of a peculiarity by persons, and only by persons, who do not possess it themselves,

seems to contravene all known laws of heredity, for by heredity is understood the transmission to offspring of the characteristics of the parent.

Perhaps the tendency to hemorrhage is common to all members of the affected families, but its overt manifestation in the women is prevented by some peculiarity of the female organism. Further study of the causes and nature of this strange disease may clear up also the mystery of this singular law of heredity.

[Translator's Note.—The explanation suggested above would not cover the remarkable fact that the sons of "bleeders" are immune. The law must not be confounded with the familiar transmission of secondary sexual characteristics by (or through) a parent of the opposite sex, for these are transmitted also by a parent of the same sex.]

AN EXPERIMENTAL STUDY OF ELECTRIC WAVES AND THEIR APPLICATIONS.

By Dr. Edouard Branly.

Electric vibrations comparable to sonorous and luminous vibrations have been observed, but, while every source of sound or light is the seat of vibratory motion, electric vibrations are produced only under special conditions. Constant electric currents, for example, can not be classed among phenomena of vibration.

The study of electric vibrations includes the description of the circumstances of their production, the indication of their applications, especially to wireless telegraphy, and, finally, the demonstration of the phenomena of interference.

Oscillatory Discharge of a Condenser.—The sparks produced by an electric machine, a Leyden jar, or an induction coil are accompanied by *isochronous* electric vibrations. In general, vibrations occur in ordinary discharges of condensers.

The discharge of a condenser is continuous or oscillatory according, on the one hand, to the capacity of the coating, and, on the other, to the resistance and the self-induction of the circuit traversed by the discharge.

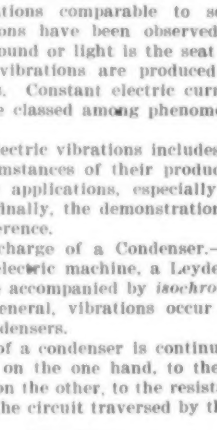


FIG. 1.

Continuous Discharge.—If the resistance of the circuit is sufficiently great, there is a continuous discharge from one coating to the other. The current of discharge increases from zero to a maximum, then decreases, and at last vanishes. The spark is very bright. Seen by reflection in a rotating plane mirror, it appears single and elongated in the direction of rotation.

Oscillatory Discharge.—When the circuit of discharge consists entirely of large metallic rods of small resistance, the spark appears, in the rotating mirror, as a series of distinct bright lines, equidistant, close together, and diminishing in intensity from the beginning to the end of the series. A single spark may exhibit a hundred of such consecutive lines. These lines correspond to currents which flow alternately in opposite directions, because that surface of the condenser which at first was positive, becomes negative, then positive again, and so on. The changes of sign succeed each other at extremely short intervals of time, 1/10,000 second or less, and, owing to the persistence of impressions on the retina, the series of sparks of discharge appears to the unaided eye as a single spark.

The frequency of alternation of a spark discharge increases as the capacity of the condenser and the self-induction of the circuit diminish. It is called a high frequency in comparison with the alternating currents used in practice, in which the number of cycles per second is little more than one hundred.

Inductive Effects of Oscillating Discharges.—The inductive effects of oscillating discharges are particularly interesting. As each of these discharges is composed of distinct currents, which succeed each other at very short intervals, the variations of these currents are exceedingly rapid, and give rise to induced currents of very high electromotive force.

The induction takes place through air and dielectrics, like induction due to motion. The high frequency of the discharges makes possible the production of inductive effects of great intensity and at great distances.

Tesla and D'Arsonval Currents.—Tesla and D'Arsonval caused the oscillatory discharge of a condenser to traverse the coarse wire circuit of a transformer. The secondary circuit of the transformer then became the seat of induced currents of frequency equal to that of the primary currents and the discharge of the condenser.

If the secondary wire is long and fine, the induced currents acquire a voltage higher than that of the primary currents, and are effective through great resistances.

If the secondary wire is short and thick, like the

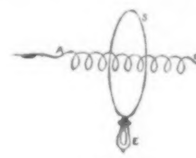


FIG. 2.

FIG. 3.

primary, the induced currents gain, not in voltage, but in strength.

The following experimental arrangement (Fig. 1) is suitable for the continued production of currents of high frequency.

An induction coil, operated by means of a continuous current and air interrupter, charges a condenser (C) which is discharged through a second induction coil.

The ends of the secondary circuit of the first coil (l, m) are connected to the poles of the condenser (C). A spark gap (cg) allows the direct, but not the inverse induced current to pass, and thus enables the condenser to become charged. The discharge of the condenser takes place between the balls (a, b) of an exciter, and traverses the short and coarse primary wire (I) of an induction coil which does not contain an iron core.

Every time the condenser, C, is discharged through a b, the discharge currents of high frequency induce, in the long, fine secondary wire (i') of the second coil, currents of the same frequency and very great electromotive force.

This high voltage is due: 1, to the very rapid variation of the successive currents of a discharge; 2, to the fact that the secondary or induced current contains a great many turns of wire whose differences of poten-

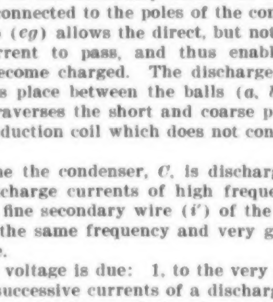


FIG. 4.

tial are added together. The ends (p, r) of the secondary circuit are connected to two metallic conductors (M, N).

If the secondary wire is short and thick, the frequency remains the same, and the current strength may become considerable.

Properties of Currents of High Frequency.—1. With secondary circuit of long fine wire.—Long sparks are obtained by separating the balls, M and N. If the balls are replaced by two vertical disks, and these are drawn apart, a tube of rarefied gas placed between them becomes luminous.

2. Secondary Circuit of Short Coarse Wire.—If the primary wire of the second induction coil is in the form of a helix (A B, Fig. 2), which is surrounded, not by a long fine wire coil, but by a single loop of heavy copper wire in which an incandescent lamp is intercalated, this lamp becomes luminous. The electromotive forces due to the several turns of the inducing helix are added together in a secondary circuit composed of a single loop of low resistance, and the current strength is correspondingly augmented.

The physiological properties of these currents have been investigated and utilized by M. D'Arsonval.

Radio-conductors.—In the preceding experiments the

FIG. 5.

inductive effects of currents of high frequency were produced at short distances only. The discovery of radio-conductors has made it possible to observe the propagation of inductive action to great distances.

M. Branly's Experiments.—In electrical science a distinction is drawn between conductors and insulators. A conductor allows electricity to pass, an insulator arrests it. In 1890 M. Branly made known a third class of bodies, which become conductors or insulators at the will of the experimenter.

To demonstrate this peculiar conductivity, metal filings are introduced, without appreciable pressure, into a glass tube (V) between two metal rods (a, b, Figs. 3 and 4) and the apparatus is intercalated in the circuit of a battery and galvanometer. If the filings have been properly selected, no current flows, and the galvanometer remains at zero. Now, if a Wimshurst machine provided with a condenser, or an exciter, connected with an induction coil, is worked near the tube, or even at a distance of 80 or 100 meters from

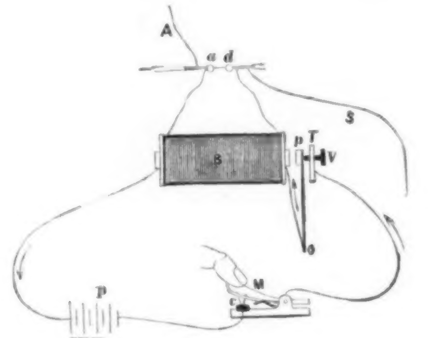


FIG. 6.

it, the prompt movement of the galvanometer needle on the passage of a spark shows that the filings have *suddenly* become a conductor. This is due to the production of induced currents of high voltage, due to the oscillating spark discharge, which currents traverse the circuit of the tube of filings. The conductivity persists after the sparks have ceased. In a lecture experiment the galvanometer is advantageously replaced by an electric bell (Fig. 5) which at first remains silent, but rings as soon as a spark discharge occurs near it. A sharp blow on the tube re-establishes the resistance of the filings, and the bell stops ringing.

The action exerted by the spark upon the tube of filings, at a distance, is increased by putting a long metal rod in contact with the exciter.

Substances which possess the property of passing in this manner from the condition of insulators to that of conductors are called radio-conductors. This name denotes that their conducting power is established under the influence of the electric vibration which emanates from a spark. Among radio-conductors some, such as metal filings, are visibly discontinuous; others, like a column formed of steel balls in contact or a metal rod resting on a steel plate, exhibit no apparent discontinuity.

The effect is produced in the open air, and the action is also transmitted through walls and partitions* but a radio-conductor inclosed, with its circuit, in a complete metallic envelope is not affected.† A few centimeters of sea water afford the same protection.

We see that a radio-conductor intercalated in the circuit of a battery behaves, at first, like an insulator and keeps the circuit open, then it becomes a conductor, and closes the circuit as soon as a spark is formed. Thus we have the means of producing at a distance, without a connecting wire, at a given instant, and even across obstacles, the various effects of the current: magnetization, incandescence, electrolysis, explosions, luminous effects, etc.

The conductivity of a radio-conductor is destroyed by shock. This enables us to make the action of radio-conductors intermittent, like that of electro-magnets. The circuit is made by a spark, and broken by a blow.

Wireless Telegraphy.—Chappe's system of signaling, and optical telegraphs are examples of wireless telegraphy. The idea of electric wireless telegraphy might have been suggested by Faraday's experiments

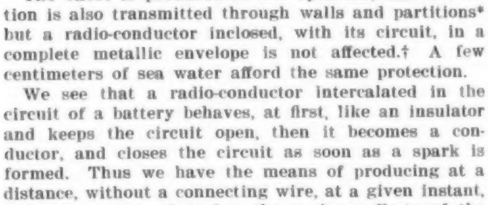


FIG. 7.

on induction. In these, in fact, an inducing circuit acted upon an independent induced circuit *at a distance*, and the effects of the electric current could be produced there by making and breaking the inducing circuit. But the distance by which the two circuits may be separated with destroying the action is too small to permit the ordinary phenomena of induction to be utilized in this way.

It was by taking advantage of the creation of conductivity in a radio-conductor by the inductive action

* This transmission is only relative, for even with very sensitive radio-conductors Branly and Le Bon observed that the electric waves failed to penetrate walls of Portland cement 30 centimeters in thickness.

† The metallic envelope must have no elongated fissure. Very small holes are without effect and a fine netting gives the same protection as a continuous sheet of metal.

of an oscillating discharge, and the destruction of this conductivity by a blow, that M. Marconi realized the transmission of signals between two distant stations not connected by a wire. By substituting a Morse receiver for the galvanometer of M. Branly's first experiments, he obtained written messages.*

Figs. 6 and 7 make clear, without further theoretical explanation, the installation of sending and receiving stations.

Sending Station (Fig. 6).—By pressing the key, *M*, the operator closes, for a very short interval, the primary circuit of an induction coil, the secondary circuit of which terminates in the balls, *a*, *d*, of an exciter.

The spark which passes between these balls is the seat of oscillating currents of high frequency, which induce currents in a circuit including a tube of metal filings at the distant receiving station.

The ball, *d*, is connected to earth (an arrangement which increases its capacity and the intensity of the spark) and the ball, *a*, is connected to a long wire, called an antenna, which extends the range of the inductive action.

Receiving Station (Fig. 7).—The poles of a battery, *P*, are connected through a tube of filings, *b*, of which one end is connected to earth and the other to the antenna, *A*. A spark at the distant sending station converts the tube of filings into a conductor and thus closes the circuit of the battery.

At this moment the electro-magnet, *E*, of a Morse receiver attracts the contact piece, *D*. The point, *p*, is raised and pressed against the moving paper, *F*. The result is a *dot*.

At the same time another electro-magnet, *G*, in circuit with the electro-magnet, *E*, is actuated and attracts the contact piece, *H*, the movement of which causes the hammer, *f*, to strike the tube, and the conductivity of the filings is instantly destroyed.

On the occurrence of a second spark of short duration at the sending station, the same effect is repeated and a second dot is formed. A *dash* composed of several dots close together is produced by prolonging the pressure of the finger on the key, *M*. The dots and dashes compose the Morse alphabet.

Branly's Receiver.—Fig. 8 represents a receiver which is simpler than the preceding, and, at the same time, more sensitive and more rapid in action.

The radio-conductor used is not a tube of filings, but a tripod disk, composed of a tripod, *T*, with points of polished steel (or cobalt), resting on a polished steel disk.

The current from a battery enters the apparatus at the binding post, *P*, whence it flows to the disk, *D*, and, entering the tripod, *T*, through the points, *a*, goes on to the screw, *V*, which presses on the little platinum plate, *o*, whence the current flows through the wire, *f*, to the second binding post, *P'*.

The closure of the circuit by a spark takes place at the contacts of the points, *a*, with the disk.

At this moment the electro-magnet, *B*, of the Morse instrument is traversed by a current and attracts the contact piece, *c*, thereby separating the platinum plate, *o*, from the screw, *V*, and opening the circuit of the radio-conductor. As the pallet, *c d*, descends the other end of the lever rises, and the point, *p*, is pressed against the paper ribbon, *I*, marking a *dot* if spark discharge at the sending station is of short duration.

The end, *d*, of the descending pallet strikes the screw, *h*, which serves as a stop and limits its play. The shock, transmitted to the tripod disk, destroys the conductivity of the contacts.

A second short spark marks a second dot, while a more prolonged discharge makes a dash. Put in circuit with only a battery cell and a *telephone*, the tripod disk permits the distance of transmission to be increased. With this arrangement the signals are not printed. The decohering blow is not needed, as the variations of resistance of the contacts determine the dots and dashes, which are *heard* through a telephone. In this case it is advantageous to replace the steel-pointed tripod by one with sharp points of aluminium, but the polished steel disk should be retained.

At present, wireless telegraphy affords the certainty of communication to a distance of at least 400 kilometers (250 miles). The electric vibrations are propagated in all directions, and affect any receiver containing a radio-conductor which may be within the sphere of influence. This universal dissemination is inconvenient in some cases, but it becomes an advantage when it is desired to promulgate information in all directions from a central station.

Hertz's Experiments.—The observation of the spark discharge of a condenser with the aid of a rotating mirror had proved the oscillatory character of the spark and the isochronism of the oscillations. It is to Hertz (born 1857, died 1893) that we owe the exact demonstration of the vibratory nature of the discharge by the production of phenomena of interference and resonance. The occurrence of interferences proves that an electric vibration is formed of two equal and symmetrical parts, like a sonorous or a luminous vibration.

At the same time Hertz proved that electric vibrations are propagated by the *ether*, that is to say, by the same medium that transmits luminous vibrations. He also recognized that electric vibrations, like light waves, are transversal. It results, from all his researches, that the only difference between electric and light waves is in the *period* of vibration. Indeed, all the undulatory phenomena of optics are repeated in electric vibrations.

We may then regard electric waves precisely as we regard the waves of light, and the terms period, wave length, and wave surface need not be defined anew.

Hertz's Exciter.—The minimum period of vibration of the discharge of a Leyden jar in the experiments of Tesla and D'Arsonval is little less than 1/100,000 sec. Hertz, by diminishing the capacity and the self-induction of the two conductors which determine the discharge, succeeded in obtaining periods ten thousand times shorter.

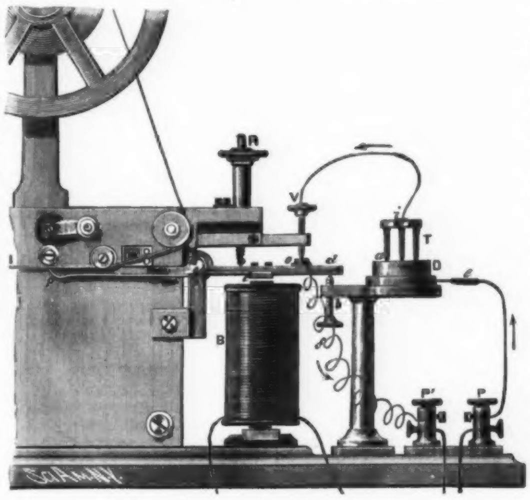


FIG. 8.

For this purpose he employed a simple exciter, formed of balls of suitable dimensions connected to the secondary circuit of an induction coil (Fig. 9). When the difference of potential of the two confronting balls has attained a certain value, a spark passes and the charges of the separate halves of the exciter combine. The phenomena of induction due to these discharges are very marked because of the extremely high frequency of their oscillations. If two metallic surfaces are brought near together in any part of the room, a spark passes between them.

Hertz's Resonator.—The *fundamental* apparatus of Hertz's experiments is his resonator (Fig. 10). This is a heavy wire bent into a circle, with a small ball, *d*, at one end, and a screw, *e*, moving in a nut at the other. By varying the distance between the front of the screw and the ball, Hertz discovered that, at a constant distance from the exciter, the length of the induced spark is a maximum for a circle of a certain radius. From this he concluded that the wire ring acts as a resonator, and that it is the seat of vibrations of a period equal to that of the inducing vibrations. The phenomenon, in fact, is analogous to the reinforcement of a musical note by a resonator of suitable dimensions.

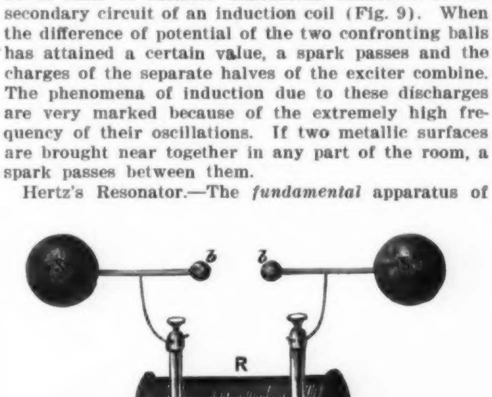


FIG. 9.

Interference by Reflection.—Electric vibrations may be reflected, refracted, and caused to exhibit phenomena of interference.

If the exciter is caused to spark before a reflecting obstacle, such as a large plate of metal, the existence of *nodes* and *loops*, analogous to those of acoustics and optics, may be detected.

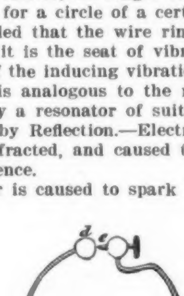


FIG. 10.

The reflecting surface is a node, and the first loop is at a distance from that surface equal to $\lambda/4$, one-fourth of the wave length of the vibration of the spark. A node is found at the distance $2\ \lambda/4$, a loop at $3\ \lambda/4$, a node at $4\ \lambda/4$ etc.

Hertz determined the positions of the loops by seeking, with a resonator tuned to the period of the exciter, points where the length of the induced spark, or the striking distance between the ball, *d*, and the point, *e*, was a maximum. The nodes are at points where the length of the spark is a minimum.

Radio-conductors may be employed in the experimental determination of the nodes and loops, but their extreme sensitiveness often makes the determination difficult.

The distance between two consecutive nodes is $\lambda/2$, or half the wave length of the spark vibration. From the equation $\lambda = V\ T$, the velocity of propagation, *V*, may be reduced if *T*, the time of vibration, is known. The theoretical equation $T = 2\ \pi \sqrt{C\ L}$ gives *T* in terms of the capacity, *C*, and the self-induction, *L*, of the halves of the exciter. The resultant value of *V* is equal to the velocity of light, 300,000 kilometers. This agreement indicates that electric vibrations are propagated by the ether.

Hertz diminished the period in order to obtain values of λ small enough to permit the distance between consecutive nodes to be measured easily, but still he used wave lengths of several meters.

By reducing the dimensions of the exciter, much shorter electric waves than those of Hertz have been obtained—some as short as 6 millimeters. But it must be noted that, in these conditions, the distance to which the inductive effect can be observed is considerably diminished, because the quantity of electricity involved in the discharge is very small. It may be added, in conclusion, that, by making these very short waves a hundred times shorter, we should obtain vibrations of the ether which would be *calorific*. There would then be no gap between the electric spectrum and the luminous spectrum.

* M. Marconi's attempts have been repeated in other countries. In France M. Ducretet was the first to construct apparatus available for use in wireless telegraph stations.

THE WHITE SANDS OF NEW MEXICO.

NATURE has been very lavish in the United States, displaying such a variety of wonderful contrasts in her handiwork as to stagger the mind in its attempt to classify them or to make a comparison of their features of relative superiority. But most of these places of interest have had their natural beauty marred to some extent, and only those in the most isolated localities have been preserved in their primeval simplicity and grandeur. However, out in the great Southwest, where the size of corner lots is that of quarter sections and where dry air is the chief asset, there are some unusual scenic attractions which are being visited each year by rapidly-increasing numbers of tourists. Among these places of interest may be mentioned the Grand Cañon of the Colorado, the Petrified Forest of Arizona, and the Enchanted Mesa of New Mexico. But however much may be said regarding these there is yet another that is more remarkable in some respects than any of the ones just mentioned. Neither has it been subjected to artificial changes nor made hideous by offensive and vulgar bill boards as has been done elsewhere, as for example at Niagara Falls. It might also be stated regarding these greater attractions of the West that there the tourist will find out-door freedom. No doubt he will prefer the fellowship of the rattlesnake, the centipede, and the tarantula to the horde of persistent beggars who constantly pursue the tourist at Niagara Falls and insist upon offering unnecessary services for cash.

On the great desert plain lying between the Organ and San Andreas Mountains on the west and Sacramento Mountains on the east, in southern New Mexico, at an altitude of about 4,000 feet above sea level, there is a wonderful exhibit of nature. Locally, it is known as the "White Sands," or simply "the sands." A more technical name is the "Gypsum Hills," because it is not sand at all but a vast deposit of nearly pure gypsum. The deposit is so unusual, its quantity so great, and its appearance so beautiful and unexpected that the spectator is amazed when he first beholds it. The gypsum is of a nearly pure white color. It is of a finely divided granular form, with the grains rounded and smooth resembling patent process white corn meal. It has drifted before the prevailing northerly winds into hillocks, some of which are about 30 or 35 feet high. These hillocks cover an area of probably 10 by 20 miles, the greater extension being northward by southward.

The conditions causing the presence of this gypsum were probably brought about through the remarkable and extraordinary changes associated with one or more volcanic eruptions that occurred many centuries ago, and which made this region one of desert dryness. Also a large section of this southwest country was probably at one time the bottom of an inland sea, and the immense beds of gypsum, now visible in the surrounding country, were deposited from the water. The soluble salts were deposited as the water disappeared and large quantities have since leached out and have been drifted by the winds into mounds from the surface of the dry soil.

Away to the north of the Sands rises the crater of an extinct volcano, standing like a grim sentinel and watching the results of its wanton destruction. The black lava, obsidian, filled the bed of a large river, which was flowing through the valley at that time, diverting the river to another valley and made what is now an almost impassable plain called the "Bad Lands," or *Mal Pais*.

The White Sands begin near the southern end of the Mal Pais and lie southwest of the remaining portion of the old river bed, which is at present a wide, deep, and dry chasm cut into the alkali earth. It is claimed by a Spanish legend that a beautiful valley, inhabited by a prosperous people, was here before the eruptions occurred and destroyed the river and brought about the present desolation.—From article by Frank W. Brady in Mines and Minerals.

ELECTRICAL NOTES.

The electro-magnet bears the same relation to electrical machinery that the cylinder, piston, and crank bear to the steam engine. Wherever we wish to translate mechanical into electrical energy, or electrical back into mechanical energy, we are compelled to use the "core and coil."

Although we are all agreed that the development of electrical storage is desirable from every point of view, engineers are still divided into two camps, those who believe in storage in its present stage of development, and those who hold the contrary opinion, that until we have at command a form of electrical storage differing widely from that furnished by the lead-couple accumulator of Planté, we had better leave storage severely alone and trust to careful design and the parallelizing of our generating apparatus or to similar precaution to obtain sufficient regularity of supply to our users.

The recent introduction of high-speed turbo-generators has called attention to the difficulties of designing both the cores and the winding of revolving fields so that they can successfully withstand the severe mechanical stresses to which they are exposed at these extreme speeds. Much ingenuity has already been exercised in attempting to reconcile the antagonistic requirements of great mechanical strength to resist centrifugal forces combined with minute sub-division of the core to prevent a free path for the eddy currents. It will be seen that here the difficulties of the designer are very great and the problem of overcoming them is yet in its early stages.

Up to the present we have been content with the older method of fibrous insulation, sometimes untreated, but in other cases impregnated with an insulating varnish or enamel. In order to render our coils non-hygroscopic, so that we can maintain sufficient insulation in moist atmosphere, we have already introduced vacuum machinery to remove the moisture after they are wound and afterward we inject our waterproofing and insulating varnishes under pressure to fill up as far as possible the interstices, at all events in the outer layers of winding, at the same time we slightly increase the heat-conducting qualities of the coil as a mass. But, unfortunately, it is difficult by such impregnation to make the coils waterproof to a satisfactory extent, for the fact that when these coils are at work they are alternately heated and cooled, of itself tends to aid the re-entrance of moisture, at all events in this climate.

The heavy cost of upkeep of the early accumulators was due to the fact that the active material on which storage capacity depends, became detached from the plates and fell to the bottom of the cells in the form of an inert mud, which required to be removed at frequent intervals of time, and was a great source of loss and annoyance. The value of recent improvements may be gaged by the fact that the formation of deposit in the bottom of the cells from this detached active material has been reduced to one-quarter of its quantity during the last five years, and we may safely say that the durability has increased and the cost of upkeep has been reduced in the same proportion. These improvements have been noticed by those who have closely studied this question, and have been followed by a great increase in the use of storage, especially where the demand on the electrical energy has been intermittent, or has been confined to short hours, such as in towns or villages where the demand up to the present has been principally for domestic purposes during hours when artificial light is required; so that at present we can design far the most economical plant for supplying electrical energy for these cases by combining the most economical generating plant that we know of, which is the combination of the internal-combustion engine with a suction gas-plant worked for long hours, and thereby charging storage sufficient to deal with the bulk of the load, but supplying the short hours of peak load from steam plant specially designed to work for short hours at a maximum efficiency.

Probably the branch of electrical engineering, which has already made its greatest advances, has been that of perfecting our measuring instruments. The instruments that we have already at command for measuring direct currents, are already so accurate and so low-priced that they are commencing to be used for many purposes quite outside the field of electrical engineering proper. By combining them either with a thermal couple, such as copper-constantan, iron-constantan, or with a platinum-rhodium or similar alloy, they become the most accurate and convenient methods of measuring temperature from the minute changes necessary in measuring lunar radiation up to extremely high temperatures close to the melting point of platinum. The standard methods of checking these coil-instruments by means of the potentiometer are already very perfect, but when we come to the measuring of alternating energy, although the instruments for measuring separately the current and pressures are satisfactory, yet no completely satisfactory method at all approaching the accuracy and simplicity of the direct current methods for measuring power are as yet available in this case. This is due to the difficulty of measuring current and pressure simultaneously and under such conditions that no corrections have to be made for the difference in phase between the two, wherein lies the all-important power factor. Probably the solution of this problem lies in the further perfecting and simplification of electrostatic means of measuring alternating pressures. Much is to be hoped for from the further development of the beautiful spherical electrostatic instruments devised by Price.

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